Issued May 1943

Soil Survey

Blackfoot-Aberdeen Area Idaho

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and
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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
University of Idaho College of Agriculture
and Agricultural Experiment Station

For sale by the SUPERINTENDENT OF DOCUMENTS, U. S. GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C. - Price 60 cents

This publication is a contribution from

BUREAU OF PLANT INDUSTRY

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Series 1937, No. 6 Issued May, 1943

SOIL SURVEY OF THE BLACKFOOT-ABERDEEN AREA, IDAHO

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United States Department of Agriculture in cooperation with the University of Idaho College of Agriculture and Agricultural Experiment Station

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[1] The field work for this survey was done while the Division of Soil Survey was a part of the Bureau of Chemistry and Soils.

HOW TO USE THE SOIL SURVEY MAP AND REPORT

The soil survey map and report of the Blackfoot-Aberdeen area contain information—both general and specific—about the soils, crops, and agriculture of the area. They are prepared for the general public and are designed to meet the needs of a wide variety of readers. The individual reader may be interested in some particular part of the report or in all of it. Ordinarily he will not have to read the whole report to gain the information he needs.

Readers of soil survey reports may be considered to belong to three general groups: (1) Those interested in limited areas, such as communities, farms, and fields; (2) those interested in the county or area as a whole; and (3) students and teachers of soil science and related agricultural sciences. An attempt has been made to satisfy the needs of these three groups by making the report a comprehensive reference work on the soils and their relation to crops and agriculture.

The readers whose chief interest is in limited areas, such as some particular locality, farm, or field, include the farmers, agricultural technicians interested in planning operations in communities or on individual farms, and real estate agents, land appraisers, prospective purchasers and tenants, and farm-loan agencies. The first step of a reader in this group is to locate on the map the tract with which he is concerned. The second step is to identify the soils on the tract. This is done by locating in the legend on the margin of the map the symbols and colors that represent the soils in the area. The third is to locate the name of each soil in the table of contents, which refers the reader to the page or pages in the section on Soils and Crops, where each soil is discussed in detail. Under the soil-type heading he will find a description of the soil and information as to its suitability for use and its relationships to crops and agriculture. He also will find useful information in the sections on Productivity Ratings and Physical Land Classification; Soil Management, Land Use, and Farming Methods; and Irrigation, Drainage, and Alkali.

The second group of readers includes persons interested in the area as a whole, such as those concerned with land use planning, or the placement and development of highways, power lines, urban sites, industries, community cooperatives, resettlement projects, private or public forest areas, recreational areas, and wildlife projects. The following sections are intended for such users: (1) Area Surveyed, in

which such topics as physiography, vegetation, water supply, population, and cultural developments are discussed; (2) Agricultural History and Statistics, in which a brief history of the agriculture of the area is given and the present agriculture is described; (3) Productivity Ratings and Physical Land Classification, in which the productivity of the soils is given and a grouping of soils according to their relative physical suitability for agricultural use is presented; (4) Soil Management, Land Use, and Farming Methods, in which the present use and management of the soils are described, their management requirements are discussed, and suggestions for improvement in management are made; and (5) Irrigation, Drainage, and Alkali, in which the problems pertaining to those subjects are treated.

The third group of readers includes students and teachers of soil science and allied subjects, such as crop production, forestry, animal husbandry, economics, rural sociology, geography, and geology. The teacher or student of soils will find the section on Morphology and Genesis of Soils of special interest. He will also find useful information in the section on Soils and Crops, the first part of which represents the general scheme of classification and a discussion of the soils from the point of view of the county as a whole, and the second part of which presents a detailed discussion of each soil. If he is not already familiar with the classification and mapping of soils, he will find that discussed in Soil Survey Methods and Definitions. The teachers of other subjects will find the section on Area Surveyed, Agricultural History and Statistics, and Productivity Ratings and Physical Land Classification, and the first part of the section on Soils and Crops of particular value in determining the relationships between their special subjects and the soils in the county. Soil scientists or students of soils as such will find their special interest in the section on Morphology and Genesis of Soils.

AREA SURVEYED

LOCATION AND EXTENT

The Blackfoot-Aberdeen area is situated in Bingham County, in southeastern Idaho (fig. 1). This area embraces most of the irrigable land along the Snake River, which flows in a southwesterly direction through the county. Blackfoot, the county seat, is about 200 miles north of Salt Lake City, Utah, and 205 miles by air line east of Boise, Idaho. The area includes 492 square miles, or 314,880 acres.

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The area lies entirely within the Snake River Plain, a high plateau forming a wide intermountain belt in southern Idaho. The topography of this plain [2] has been determined largely by successive lava flows and is only slightly modified by erosion, chiefly by the Snake and Blackfoot Rivers. Within the area surveyed these two rivers have, by erosion and deposition, given rise to the main features of relief, as the tributary streams are intermittent, have poorly defined channels, and carry very little sediment. In the valleys of these

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[2] STEARNS, H. T., CRANDALL, LYNN, and STEWARD, WILLARD G. GEOLOGY AND GROUND WATER RESOURCES OF THE SNAKE RIVER PLAIN IN SOUTHEASTERN IDAHO. Idaho Bur. Mines and Geol. and Idaho Dept. Reclam. [Mimeographed.]

rivers the relief is dominated by smooth comparatively flat alluvial terraces at successive elevations and of variable age. Skirting the edges of the valley floor, the irregular Snake River basalt, barren or thinly mantled with loess, gives rise to rolling to hilly uplands (fig. 2, 1).

Much of the northeastern part of the area, on both sides of the Snake River, is occupied by the gravelly Gibson terrace (*11*).[3] Distinct bluffs form the edges of this terrace, separating it from the bottom lands, higher terraces, and uplands. Eroded channels and alluvial deposits are conspicuous where not removed or obscured by leveling in agricultural development. In the eastern part of the terrace, wind and water erosion and accumulation of material have contributed to a very irregular surface, with many dunes and hummocks. The gravelly substratum of this terrace contributes to the rapid movement of underground water, and the soils are excessively drained. A few exceptions are noteworthy where clay is interbedded.

FIGURE 1.—Sketch map showing location of the Blackfoot-Aberdeen area, Idaho.

The Snake River, running over or near basalt bedrock, has cut 30 to 40 feet into this terrace near Shelley. The terrace here lies about 4,624 feet above sea level. Near Blackfoot, at an elevation of 4,497 feet, where the Blackfoot River joins the Snake River, the flood plains widen and the rivers meander through an area of riverwash. Here the terrace lies 15 to 20 feet above the river. Below this point the Snake River occupies a low marshy flood plain together with Clear and Spring Creeks, which rise from springs issuing from under the terrace. In the south end of the area these streams empty into the American Falls Reservoir, which now occupies their former flood plain.

[3] Italic numbers in parentheses refer to Literature Cited, p. 110.

Along the western edge of the area, from Moreland southwestward, the valley floor consists of fine-textured old lake sediments forming several terraces of a former receding lake, the Grandview-Pingree, Aberdeen, and Sterling terraces. Outcrops of the underlying basalt bedrock are common, and in some places on the upper terrace—Grandview-Pingree terrace—a knoblike to rolling relief results from this and from lake sediments being capped by masses of huge angular or subangular basalt boulders. Thus protected, the sediments have resisted erosion, whereas surrounding sediments have eroded away. The elevation of this terrace ranges from about 4,430 feet at the south to slightly more than 4,460 feet at the north.

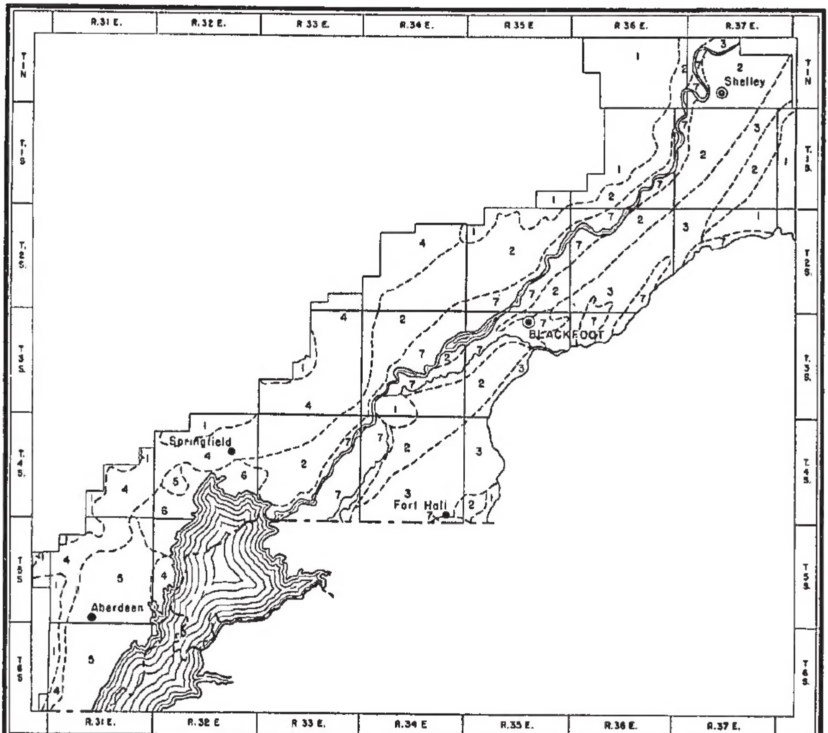

FIGURE 2.—Physiographic units of the Blackfoot-Aberdeen area, Idaho: 1, Uplands; 2, Gibson terrace; 3, Gibson terrace, dune-sand section; 4, Grandview-Pingree terrace; 5, Aberdeen terrace; 6, Sterling terrace; and 7, stream bottoms.

The Aberdeen terrace at Aberdeen is a lake terrace that lies at a remarkably uniform elevation of about 4,400 feet. Between this and the higher terrace is a steep bluff. Drainageways cutting across these terraces are bordered in many places by bluffs, and the larger of these run back into the uplands, conspicuously modifying the relief.

The lowest lake terrace surrounding the American Falls Reservoir is the Sterling terrace. This has an average elevation of about 4,380 feet, which is about 20 feet above the high-water level of the reservoir. Both the Aberdeen and Sterling terraces are separated from the reser-

voir by distinct bluffs. Both appear to have been invaded by streams, as they generally have a thin mantle of gravel and sand and contain a few gravel lenses. The boundary between the Sterling and Aberdeen terraces is less marked than that between the Sterling and Grandview-Pingree terraces.

Most of the Sterling terrace is poorly drained. The underlying clay strata restrict free movement of water, and springs and surface water are common. Springs issue from the underlying basalt in the vicinity of Springfield, and the terrace shows evidence of a rising water table, as many alkali areas are appearing. Oversaturation in this area is attributed to irrigation.[4]

Except along the Snake River below the mouth of the Blackfoot River, the stream bottom lands generally are well drained. East of Blackfoot surface water appears in small basins where underlying clays force the water to the surface. This is in the sand-dune section of the Gibson terrace, where drainageways are absent or poorly developed. Before irrigation began, these basins were known as the sinks of Sand Creek. Seepage from irrigation has caused the wet salty (alkali) areas to increase in number and in size.

VEGETATION

Except on the wet bottom lands, the native vegetation is almost all big sagebrush (*Artemisia tridentata* Nutt.). There is a scattered growth of bunchgrasses in places, generally in protected areas or areas of deep sand. In the sand-dune section the sand dunes and hummocks support a scattered growth of bunchgrasses and flowering herbs almost to the total exclusion of the sagebrush. In places where a high water table is encroaching, owing to seepage from irrigation, sagebrush dies, and saltgrass and greasewood (*Sarcobatus vermiculatus* (Hook.) Torr.) succeed it. This cover, together with scattered saltbush, is also the native vegetation on naturally poorly drained salty areas.

In addition to sagebrush, on the gravelly alluvial bottoms of the Snake River, where moisture is more plentiful, as along stream channels, cottonwood, willow, and brush usually flourish. In the back bottoms below Ferry Butte and at the confluence of the Snake and Blackfoot Rivers, the open marshy meadows support cattails, rushes, reeds, and water-tolerant grasses. Here a considerable quantity of native hay is produced and pasturage is afforded. Meadows along the Blackfoot River also support similar vegetation, and channels are lined with cottonwood, willow, and brush.

The following are some of the important plants in the area:[5]

Sagebrush association: Big sagebrush (*Artemisia tridentata* Nutt.), rubber rabbitbrush (*Chrysothamnus nauseosus* (Pallas) Britton), rubber rabbitbrush (*C. graveolens* (Nutt.) Greene), squirreltail (*Sitanion hystrix* (Nutt.) J. G. Smith), red three-awn (*Aristida longiseta* Steud.), downy chess (*Bromus tectorum* L.).

Sand-dune association: Ragweed (*Ambrosia psilostachya* DC.), bitterbrush or antelope-brush (*Purshia tridentata* (Pursh) DC.),

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[4] See footnote 2, p. 3.

[5] Plants identified by J. H. Christ, of the Soil Conservation Service, U. S. Department of Agriculture.

sorrel (*Rumex venosus* Pursh), wild-rye (*Elymus flavescens* Scribn. and Smith), sand dropseed (*Sporobolus cryptandrus* (Torr.) A. Gray), turnspike wheatgrass (*Agropyron dasystachyum* (Hook.) Scribn.), Indian ricegrass (*Oryzopsis hymenoides* (Roem. and Schult.) Ricker), needle-and-thread (*Stipa comata* Trin. and Rupr.), horsebrush (*Tetradymia inermis* Nutt.), scurfpea (*Psoralea lanceolata scabra* (Nutt.) Piper), arrowleaf balsamroot (*Balsamorhiza sagittata* (Pursh) Nutt.), false tarragon (*Artemisia dracunculoides* Pursh).

Stream-bottom association: *Glycyrrhiza lepidota* Nutt., virginsbower (*Clematis ligusticifolia* Nutt.), lemonade sumac (*Rhus trilobata* Nutt.), greasewood (*Sarcobatus vermiculatus* (Hook.) Torr.), sedge (*Carex* sp.), saltgrass (*Distichlis spicata* (L.) Greene), beardless wheatgrass (*Agropyron inerme* (Scribn. and Smith) Rydb.), quackgrass (*Agropyron repens* (L.) Beauv.), wild-rye (*Elymus* sp.), foxtail barley (*Hordeum jubatum* L.), *Astragalus* sp., giant wild-rye (*Elymus condensatus* Presl.), rush (*Juncus* sp.), alkali sacaton (*Sporobolus airoides* (Torr.) Torr.), western wheatgrass (*Agropyron smithii* Rydb.), tailcup lupine (*Lupinus argenteus* Pursh), *Plantago asiatica* L., milkweed (*Asclepias speciosa* Torr.), Nutka rose (*Rosa nutkana* Presl.), hairy chess (*Bromus commutatus* Schrad.), shrubby cinquefoil (*Potentilla fruticosa* L.).

ORGANIZATION AND POPULATION

Bingham County, within which the Blackfoot-Aberdeen area lies, was organized in 1885 at the period of rapid development of irrigation along the Snake River. Early settlement began in the sixties on the bottom lands, where native hay and pasture were plentiful and where irrigation water was easily diverted. Expansion to the higher terraces followed when companies were organized for the purpose of the development of irrigation. The Fort Hall Indian Reservation, which lies partly in the area surveyed, was established in 1867. Development of irrigation within the reservation dates mainly from 1907. The present boundary of Bingham County was not established until 1917.

Early settlers came chiefly from Utah, and their descendants occupy much of the area at present. Other settlers came from nearly every State in the Union. In several districts the inhabitants are largely of Swedish and German extraction.

In 1930 the Federal census reported the population of Bingham County as 18,561, of which 15,362, or 82.8 percent, were classed as rural, and 11,074 actually lived on farms. The composition of the population was as follows: 88.4 percent native-born whites, 5.5 percent foreign-born whites, and the rest chiefly Indians, Japanese, Mexicans, and Chinese. The 1940 census reports an increase in population to 21,044, but as yet (1941) the number of rural inhabitants is not available. Most of the inhabitants live within the area surveyed, which represents about one-fourth of the total area of the county.

Blackfoot, the county seat, had a population of 3,681 in 1940. Shelley, which had 1,751 inhabitants in 1940, and Aberdeen, which had 1,016, are important trading and shipping centers.

TRANSPORTATION FACILITIES, PUBLIC SERVICES, AND MARKETS

Several branches of the Union Pacific Railroad provide the county with adequate railroad facilities. United States Highway No. 91, paralleling the branch line from Fort Hall through Shelley, is an important arterial highway for motor transportation. A State highway (oiled) runs from Blackfoot through Aberdeen; another branches from this at Riverside and runs northwest through the county to Mackay (in Custer County). All highways have passenger and freight bus service. The irrigated districts have graded and dragged roads on most of the section lines. In the northern part of the county naturally occurring gravel makes the roads serviceable in all kinds of weather; elsewhere roads that are not graveled become rutted and dusty in summer and muddy in winter. In addition to the oiled highways, enough roads are graveled to serve most parts of the area as main lines of transportation.

Electricity, for light and power, is available in most districts not too remote from the main transmission lines. Telephone service is available in rural communities and most outlying areas. Churches and schools are conveniently located in the towns and rural communities. Consolidated school districts supply transportation to and from centralized schools.

Local markets absorb only a small part of the agricultural products, and long hauls to Midwest and Pacific coast markets are necessary for the more important crops not processed locally.

CLIMATE

An arid continental climate is characteristic of the Snake River Plain. In this area the annual rainfall is low, the atmosphere dry and clear, the summers comparatively hot and dry, and the winters cold. Much snow falls at times. The prevailing winds are from the southwest and are common in spring and early summer, occasionally giving rise to duststorms, which are rarely destructive to property.

As in most arid regions, the annual precipitation varies widely from year to year. At Blackfoot it has ranged from 5.18 to 18.08 inches. The mean is 10.54 inches, including an average snowfall of 32.5 inches. Aberdeen, which is situated farther out from the mountains in the arid plain, has an average annual precipitation of only 8.83 inches. The precipitation occurs mostly in the fall, winter, and spring. The dry summers favor the curing of hay and seed crops.

Blackfoot, centrally located in the area, has a mean annual temperature of 44.5°F. Absolute extremes of temperature recorded are maximum, 108°, and minimum, −39°. The average date of the last killing frost is May 19 and the first is September 14. There is thus an average frost-free season of 118 days. Killing frosts have been recorded as late as June 25 and as early as August 22. These frosts endanger such crops as beans and corn, and these and other tender crops are not grown extensively. Only the most hardy fruits are grown. During the winter the ground is frozen and farm operations are suspended.

The climatic data given in table 1, taken from the United States Weather Bureau station records at Blackfoot, represent average weather conditions in most of the area.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Blackfoot, Bingham County, Idaho*

[Elevation, 4,503 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1901)	Total amount for the wettest year (1909)	Snow, average depth
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	22.9	59	−30	0.91	1.25	1.96	7.4
January	20.5	54	−39	.98	.30	3.03	9.1
February	25.3	64	−32	.79	.51	1.44	6.4
Winter	22.9	64	−39	2.68	2.06	6.43	22.9
March	34.6	79	−24	.88	.31	1.14	3.9
April	44.9	85	3	.89	.76	.12	1.7
May	53.2	95	19	1.36	.54	1.86	.1
Spring	44.2	95	−24	3.13	1.61	3.12	5.7
June	61.5	108	20	.87	.00	.55	(1)
July	68.7	103	30	.70	.23	.89	.0
August	66.4	101	23	.63	.60	1.40	.0
Summer	65.5	108	20	2.20	.83	2.84	.0
September	56.5	92	12	.84	.50	1.70	(1)
October	45.5	88	4	.99	.18	.99	1.3
November	34.0	71	−28	.70	(1)	3.00	2.6
Fall	45.3	92	−28	2.53	.68	5.69	3.9
Year	44.5	108	−39	10.54	5.18	18.08	32.5

[1] Trace.

AGRICULTURAL HISTORY AND STATISTICS

Agriculture in the area was begun in a small way prior to 1870, by settlers, mostly stockmen, who established themselves on the bottom lands along the streams. Shortly after that year the establishment of the military post of Fort Hall on Lincoln Creek, just outside the area, afforded protection and a center of supply, and agriculture began to expand into the surrounding benchlands through diversion of water for irrigation. In 1878 the Utah & Northern Railroad was built to Blackfoot. After this, companies were organized for the construction of canals and ditches and the diversion of irrigation water, and expansion was rapid. Most of this organization and development took place from 1884 to 1905, although some lands were not brought into production until 1912 and later.

The pioneer agriculture on the livestock ranches consisted chiefly of growing native hay for the winter feeding of cattle. With the expansion of agriculture onto the benchlands, the production of tame hay (mainly alfalfa), wheat, oats, and some barley became important on the irrigated lands. Most of this was consumed locally by the work animals and by cattle and sheep brought in from the ranges for winter feeding. By 1910 sugar beets and potatoes had become important crops. The acreage devoted to these crops has fluctuated from year to year, depending on their market price.

Table 2, taken from the reports of the Federal census, shows the acreage devoted to the principal crops in selected years since Bingham

County was reduced to its present size. As these crops are grown almost entirely on the irrigated lands of this area, the data are fairly representative for the area as a whole.

TABLE 2.—*Acreage of principal crops in Bingham County, Idaho, in 1919, 1929, and 1939*

Crop	1919	1929	1939	Crop	1919	1929	1939
	Acres	*Acres*	*Acres*		*Acres*	*Acres*	*Acres*
Wheat	28,342	24,168	13,302	All hay	43,868	51,847	46,463
Oats	5,521	3,606	5,460	Alfalfa	38,632	49,593	42,850
Barley	1,173	3,610	6,604	Timothy and clover, alone or mixed	1,304	781	887
Potatoes	7,397	13,377	19,347	Sweetclover		207	270
Sugar beets	9,783	8,582	11,156	Other tame hay	1,895	307	502
Peas		2,737	1,698	Wild hay	2,037	959	1,954
Beans		457	2,211		*Trees*	*Trees*	*Trees*
Alfalfa seed		10,726	8,051	Apples	77,976	29,435	11,306
Clover seed		6,074	4,048				

Agriculture in this area is highly diversified, and the average farm is usually planted to as large an acreage of cash crops as the rotation with legumes to maintain fertility will allow. Potatoes and sugar beets, the most important cash crops, compete for acreage, depending on the prospective market price. Many farmers favor sugar beets, because these are usually contracted for by local beet-sugar factories at a definite price, thus eliminating the element of risk on market fluctuation. Others prefer potatoes because of higher acre returns when potato prices are high, but they run the risk of a low market price in some years. Dry peas and to a less extent dry beans are at present in competition for acreage with the cash crops mentioned above. Peas and beans are contracted for by seed companies and therefore find favor among some farmers. Increase in acreage of these crops will depend on the market price, although climatic conditions are not so favorable for beans as for peas. Peas substitute for wheat as a nurse crop with alfalfa.

In the past the sugar-beet crop was endangered by a virus disease, curly top, transmitted by the leafhopper (*Eutettix tenellus* Baker), locally but erroneously called "white fly." The introduction of a disease-resistant variety developed by the Bureau of Plant Industry of the United States Department of Agriculture has reduced losses to a minimum, and the acreage devoted to sugar beets is again increasing. Competition between potatoes and sugar beets no doubt will be more consistent in the future, depending on the individual preference of the farmer. Climatic conditions are equally favorable for the two crops, which thrive equally well on similar soils.

Potatoes have become an important crop in this section. Climate and soil favor their growth, and injury from insects and diseases is less than in older farming sections. This crop is easily disposed of, as buying agencies are well established locally. Storage facilities have been provided on many farms, and in the towns and at railroad sidings there are cooperative and individual storage cellars. Facilities for the disposal of such bulky products as potatoes and sugar beets have been built up over a long period of years, and only short hauls are necessary from most farms.

In certain places, such as at Springfield and in some districts where

the soils are sandier, the production of alfalfa seed as a cash crop is practiced almost to the exclusion of all other crops. The growing of this crop is materially influenced by annual climatic conditions, as well as by cultural practices, soil, and drainage. Control of moisture is one of the most important factors in the production of seed, and this can be accomplished on the sloping lands at Springfield and in the sandy porous soils of other localities. Ponding of water causes too luxuriant a vegetative growth at the expense of the seed. Seed is successfully grown where underground water stands within the feeding zone of the alfalfa roots and surface applications of water withheld or carefully controlled.

The small grains, largely wheat, are grown principally because they fit into the crop rotation as a nurse crop for alfalfa during its first year. The returns from these crops are not sufficient to justify their production in competition with potatoes and sugar beets. Wheat is grown in preference to barley and oats because of the consistent market demand for this crop and because it can probably be grown with fair success on a somewhat wider range of soils.

Alfalfa occupies the largest acreage in the area, not only because of its feeding value but also because it is so useful as a part of the crop rotation necessary to maintain and increase fertility. It is usually grown for 3 or 4 years and is followed by other crops for an equal number of years. Alfalfa hay is too bulky to be shipped profitably to distant markets, and in some States a quarantine is imposed because the alfalfa weevil is an insect pest in Idaho. Therefore, most of the alfalfa has to be fed to livestock on the individual farm or sold locally for the feeding of range cattle and sheep that are brought in for winter feeding.

Red clover is used to a less extent in the crop rotation, but it is not so popular as alfalfa. This biennial crop occupies the land only 2 years and is grown principally for the production of seed.

Native hay is produced mainly on the bottom lands of the Fort Hall Indian Reservation. It is used for winter feeding of livestock on the reservation.

Crops of which small but significant acreages are reported are corn, rye, vegetables, pears, plums, prunes, cherries, strawberries, raspberries, and other berries.

Farm flocks of sheep have become popular in recent years and are pastured principally on alfalfa, sweetclover, and waste products following harvest. Hogs and cattle are pastured in a similar way. The farm livestock and cattle and sheep from the range are turned into the fields in the fall and consume waste grains, peas, beans, and beet tops and forage that has not been cut for hay. Alfalfa and clover, sown primarily for seed, are often grazed or clipped in the spring before being allowed to go to seed.

Considerable revenue is obtained from the sale of livestock. Dairying, popular on many farms, and poultry raising are supplementary sources of cash income. Garden crops and fruits are grown principally for consumption in the home. Colonies of bees are kept in various parts of the county.

Table 3, compiled from the Federal census reports, shows the number of livestock in Bingham County in selected years.

TABLE 3.—*Number of livestock in Bingham County, Idaho, in 1920, 1930, and 1940*

Livestock	1920 [1]	1930 [2]	1940 [3]	Livestock	1920 [1]	1930 [2]	1940 [3]
Horses	14,371	10,561	9,026	Sheep	97,052	179,332	94,051
Mules	119	120	39	Swine	16,574	12,983	13,833
Cattle	29,062	24,569	26,090	Chickens	76,341	91,891	103,962

[1] Livestock of all ages on Jan. 1, 1920.
[2] Livestock of all ages on Apr. 1, 1930, excluding chickens less than 3 months of age. The number excluding young animals would be considerably less.
[3] Livestock on Apr. 1, 1940, excluding horses, mules, and cattle under 3 months of age, swine and chickens under 4 months, and sheep under 6 months.

It will be noted that the numbers of horses and cattle have decreased since 1920. The increase in the number of sheep in 1930 and the subsequent decline are much less pronounced than the data in table 3 would indicate, owing to the different dates of the census and the inclusion of spring lambs in 1930. The raising of hogs, discouraged by low prices in 1930, recovered somewhat in 1940.

Application of commercial fertilizers has not become a common practice, although triple superphosphate is often used with seedings of sugar beets and occasionally with alfalfa.

American farm labor is usually available where there is a demand. Farmers often exchange work during harvest. For harvesting potatoes and beets, transient labor is usually available. Mexicans, Filipinos, and Negroes are often hired from outside the county for seasonal work in sugar-beet fields.

The size of farms ranges from a few acres near towns to several hundred acres in the rural districts. Holdings of 40 to 80 acres are the most common units.

Of the 2,217 farms reported in Bingham County by the 1940 census, 70.1 percent were operated by owners, 29.5 percent by tenants, and 0.4 percent by managers. Some rentals are made for cash, but the share system is more common. The landlord usually receives from one-fourth to one-half of the crop, depending on the crop grown and on the quantity of livestock, equipment, and seed furnished by him.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called collectively the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail, and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [6] and its content of lime and salts are determined by simple tests.[7] Drainage, both internal and external, and other external

[6] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[7] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction, and dilute hydrochloric acid to detect carbonate of lime.

features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to the features that influence the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped into mapping units, the three principal of which are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (4) miscellaneous land types.

The most important group is the series which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from one type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics; the same natural drainage conditions; and the same range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Sagemoor, Declo, and Bannock are names of important soil series in this area.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Sagemoor silt loam and Sagemoor very fine sandy loam are soil types within the Sagemoor series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, differing from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for certain soil types, some areas may be adapted to the use of machinery and the growth of cultivated crops and others may not. Even though no important differences exist in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, important differences are observed in the growth of cultivated crops. The more sloping parts of such soil types are segregated on the map as a sloping or a hilly phase. Similarly, some soils having differences in stoniness are mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The valley floor, which consists of a series of smooth terraces, forms the larger and smoother part of the area surveyed. It owes its surface configuration to extensive deposits of gravelly flood-plain alluvium and finer textured lake-laid materials superimposed upon the irregular lava beds of the Snake River Plain. In the more irregular upland skirting this valley floor, where only a thin mantle of wind-borne dustlike material has accumulated, the topography conforms to the original underlying lava beds. In a few places in the uplands along the eastern edge of the area there are evidences of older water-laid deposits contributing in a minor degree to the underlying substrata.

The soils have developed largely from the materials brought in by water and wind. Transported from outside sources, these deposits represent a wide range in origin. The underlying basalt has contributed only scattered fragments in the soil material. Flow marks of cooling lava and smooth water- and wind-worn surfaces of the basalt substratum indicate that the soils have not formed from the disintegration of this underlying rock. The water-laid materials are high in quartz and quartzite. Fragments of red, gray, and white quartzite gravel are very prominent, especially in the subsoil and substratum. Fragments of basalt are most prominent in those sandy soil materials that have been blown into hummocks and dunes by the wind.

Deposits of fine, floury, wind-borne material, such as those that mantle the uplands, have to a less degree formed a surface veneer over or have become incorporated in the alluvial soil materials of the valley floor. This fine wind-borne material, called loess, deposited from atmospheric suspension, and the uniform arid climate have given rise to extensive areas of soils that have comparatively uniform chemical characteristics and high mineral fertility. The productivity varies materially, however, because of differences in the physical make-up of the soil materials and underlying substrata, which, in turn, control soil moisture conditions. Such differences include the gravel and clay strata of the valley floor and the basalt substratum of the uplands.

Developed in this arid climate, all the soils, except those on the bottom lands or flood plains, are light-colored because of lack of organic residues from the decay of plants. On the other hand, they are little leached of the mineral elements of fertility; hence they are highly productive where additional organic matter and nitrogen are supplied by legumes in the crop rotation or by barnyard manure, and where sufficient moisture is supplied to mature the crops.

On the bottom lands, where moisture has been more plentiful, are darker colored soils that have formed because of the decay and incorporation of organic residues from a more luxuriant vegetation. When well drained they are the most productive soils of the area, because they are not leached, are high in organic matter and nitrogen, and in many places have received additional fertility from recent alluvial deposits.

For convenience of discussion, the soils and land types of the area have been classified, largely on the basis of physiographic position, relief, and stoniness, in four distinct groups as follows: (1) Soils of

the uplands; (2) soils of the terraces or valley floor; (3) soils of the bottom lands and depressions; and (4) miscellaneous land types. In most instances the differences based on occurrence and relief are apparent, but in some places the soils overlap or intergrade and certain soil types and phases included with one group are closely related to those of another main group.

In the following pages the soils of the Blackfoot-Aberdeen area are described in detail, and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in table 4.

SOILS OF THE UPLANDS

The soils of the uplands, for the most part, skirt the edge of the area surveyed. They occupy less than one-tenth of the area, but, like certain soils of the bottom lands, they are, where irrigated, among the most productive soils of the area. Probably only one-fifth of this land is under cultivation, however, as much of it lies too high for diversion of irrigation water or occurs in scattered bodies in the lava beds where the construction of canals is difficult. Dry farming has not been successful on these soils, owing to the low rainfall, and areas once cultivated are now abandoned. Conforming largely to the configuration of the underlying basalt, most of the areas are rolling to sloping, but many are smooth or nearly flat. Some of the rolling and sloping areas are rather difficult to irrigate, and some of the steep slopes are practically nonarable.

The soils of this group are light-colored, mostly light brown or light grayish brown. The soil materials are of wind-laid origin, mostly loessial or wind-borne and fine-textured. The soils are predominantly silt loams and very fine sandy loams.

Although organic matter and nitrogen are deficient in these soils under their native cover of sagebrush, the level of mineral fertility is inherently high. Therefore, if legumes are used in the crop rotation, supplemented by barnyard manure, a high level of productivity can be reached under irrigation. The smooth floury character of the material throughout gives these soils excellent storage capacity for moisture, and crops are grown with a minimum quantity of irrigation water. Tillage is easy, because of the mellowness of the soil. In places along the western edge of the area, some fields are broken by outcrops of the uneven underlying lava beds, or the soils are so shallow that tillage is difficult and the moisture-holding capacity of the soil is low.

This group of soils includes members of the Portneuf, Ammon, and Wheeler series. Strictly speaking, the Ammon soils are not in the uplands but occupy a position intermediate between the higher lying benches and the valley floor. They have been modified by the action of water and lie on smoothly sloping alluvial fans.

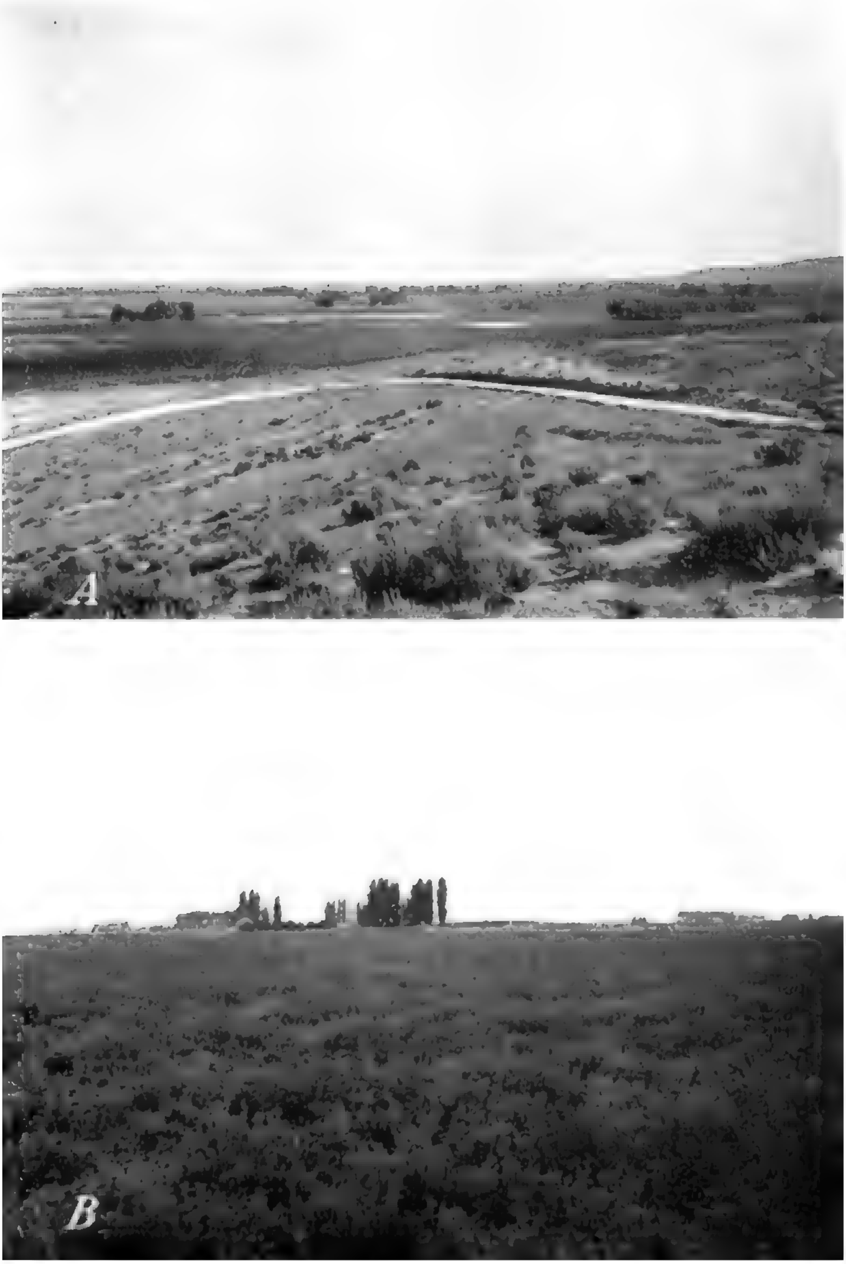
In their virgin condition, these soils do not present any striking differences in color on the immediate surface, generally being light grayish brown; but under cultivation the subsurface layer of the Portneuf soil is mixed with the surface soil, imparting a richer light brown color. In their virgin condition the Wheeler and Ammon soils in places have calcareous surface soils but generally do not contain lime

TABLE 4.—*Acreage and proportionate extent of the soils mapped in the Blackfoot-Aberdeen area, Idaho*

Soil type	Acres	Percent
Portneuf silt loam	5,376	1.7
Portneuf silt loam, rolling phase	6,016	1.9
Portneuf silt loam, steep phase	2,112	.7
Portneuf very fine sandy loam	448	.1
Portneuf very fine sandy loam, rolling phase	640	.2
Portneuf loamy fine sand	1,152	.4
Portneuf loamy fine sand, rolling phase	768	.2
Ammon silt loam	1,920	.6
Ammon silt loam, slope phase	192	.1
Ammon very fine sandy loam	384	.1
Wheeler silt loam	2,112	.7
Wheeler very fine sandy loam	1,472	.5
Wheeler very fine sandy loam, steep phase	1,920	.6
Sagemoor silt loam	5,952	1.9
Sagemoor silt loam, slope phase	4,608	1.5
Sagemoor silt loam, shallow phase	1,472	.5
Sagemoor very fine sandy loam	4,416	1.4
Sagemoor very fine sandy loam, slope phase	4,672	1.5
Sagemoor very fine sandy loam, shallow phase	3,200	1.0
Sagemoor silty clay loam	5,952	1.9
Sagemoor silty clay loam, slope phase	576	.2
Sagemoor fine sandy loam	2,368	.8
Sagemoor fine sandy loam, slope phase	2,048	.7
Sagemoor fine sandy loam, shallow phase	1,344	.4
Sagemoor fine sandy loam, steep phase	704	.2
Declo loam	2,688	.9
Declo loam, slope phase	1,216	.4
Declo loam, steep phase	1,344	.4
Declo silty clay loam	3,520	1.1
Declo silty clay loam, slope phase	768	.2
Declo silt loam	896	.3
Declo silt loam, slope phase	896	.3
Declo very fine sandy loam	576	.2
Declo very fine sandy loam, slope phase	704	.2
Declo fine sandy loam	768	.2
Declo sandy loam	896	.3
Declo sandy loam, slope phase	1,152	.4
Declo loamy fine sand	640	.2
Declo loamy fine sand, slope phase	1,280	.4
Fingal sandy loam	1,920	.6
Fingal loam	1,728	.5
Fingal loam, slope phase	320	.1
Fingal fine sandy loam	1,280	.4
Fingal fine sandy loam, slope phase	832	.3
Fingal loamy sand	3,456	1.1
Fingal sand	768	.2
Fingal sand, hummocky phase	9,280	2.9
Fingal silty clay loam	1,664	.5
Bannock silty clay loam	9,984	3.2
Bannock gravelly silty clay loam	1,280	.4
Bannock loam	12,160	3.8
Bannock gravelly loam	8,064	2.6
Bannock gravelly loam, slope phase	2,944	.9
Bannock gravelly loam, shallow phase	3,264	1.0
Bannock silt loam	4,864	1.5
Bannock very fine sandy loam	3,328	1.1
Bannock very fine sandy loam, slope phase	1,984	.6
Bannock fine sandy loam	9,856	3.1
Bannock gravelly fine sandy loam	3,840	1.2
Bannock gravelly fine sandy loam, shallow phase	2,368	.8
Bannock gravelly fine sandy loam, slope phase	2,112	.7
Bannock loamy fine sand	3,200	1.0
Bannock sandy loam	2,432	.8
Bannock sandy loam, slope phase	1,216	.4
Bannock fine sand	3,968	1.3
Bannock fine sand, hummocky phase	3,264	1.0
Paul silty clay	1,408	.4
Paul silty clay loam	960	.3
Paul loam	1,152	.4
Paul sand	640	.2
Rupert fine sand	2,112	.7
Rupert fine sand, rolling phase	7,040	2.2
Rupert fine sand, dune phase	2,496	.8
Rupert gravelly loamy sand	4,288	1.4
Winchester sand	640	.2
Winchester sand, dune phase	2,304	.7
Beverly loam	3,392	1.1
Beverly silty clay loam	1,664	.5
Beverly very fine sandy loam	6,336	2.0
Beverly very fine sandy loam, gravelly phase	1,152	.4
Beverly gravelly fine sand	1,408	.4
Beverly fine sand	512	.2
Beverly fine sand, eroded phase	1,344	.4
Blackfoot loam	4,032	1.3
Blackfoot loam, poorly drained phase	1,152	.4
Blackfoot silty clay loam	2,368	.8
Blackfoot silty clay loam, poorly drained phase	1,792	.6
Blackfoot fine sandy loam	1,472	.5
Blackfoot fine sandy loam, broken phase	2,176	.7
Blackfoot sandy loam	960	.3
Blackfoot sandy loam, poorly drained phase	2,304	.7
Blackfoot loamy sand	576	.2
Onyx silt loam	384	.1
Gooch silty clay	3,648	1.2
Gooch silty clay loam	320	.1
Snake silty clay loam	1,536	.5
Snake silty clay	1,536	.5
Snake fine sandy loam	128	[1]
Logan silty clay loam	1,920	.6
Logan sandy loam	256	.1
Scabland	44,224	14.0
Stony land	8,256	2.6
Riverwash	7,360	2.3
Rough broken land	3,776	1.2
Rough broken land (Wheeler soil material)	5,312	1.7
Total	314,880	100.0

[1] Less than 0.1 percent.

to a depth of a few inches, whereas the Portneuf soils are noncalcareous to an average depth of 12 to 15 inches. Depth of leaching is an important difference, as a high lime content limits the availability of phosphate to the plants.



A, View across part of the irrigated valley from low benchland occupied by the Wheeler soils; *B*, alfalfa on the Paul soils—mainly Paul loam.

The Ammon and Wheeler soils are without appreciable compaction or lime cementation in the subsoil, but have a definite concentration of lime. In the Portneuf soils the concentration of lime begins at a depth of about 12 to 15 inches and continues for 2 or more feet, being definitely compact and nodular. This layer is not so compact as the corresponding layer of the Sagemoor soils and is penetrated by roots readily, especially where irrigated. Below the concentration of lime in these soils is a light-gray readily penetrable smooth floury mellow yet definitely calcareous zone continuing to bedrock.

None of the Wheeler soils is farmed. The soils lie mostly on a high bench above the Blackfoot River (pl. 1), and water from this stream is the only possible source of irrigation water. Although mostly rolling to broken, these soils offer possibilities for future development, and their productivity under irrigation probably would be somewhat less than that of the smoother Ammon soils, which they most closely resemble. Almost all of the Ammon soils is farmed. Their general smoothly sloping relief makes them ideal for distribution of water under irrigation. Probably less than one-fourth of the Portneuf soils is farmed. This is due to the fact that they lie mostly along the western margin of the area where it is difficult to obtain water for irrigation and pumping is often necessary.

All the crops of the area are grown on both the Portneuf and Ammon soils, and the highest yields are obtained on them. Certain properties of each series apparently are compensating, so that similar yields are obtained on them. Although the Ammon soils generally are more calcareous in the surface soil than the Portneuf, the more compact limy subsoil of the latter offers some resistance to the penetration of roots. The high concentration of lime limits availability of phosphate to the plant, so that the Ammon soils probably will require more frequent applications of phosphate, especially for alfalfa and sugar beets. It has been observed, however, that under irrigation all the surface soils become limy, the concentration depending on the length of time the soils have been cultivated, the quantities of water applied, and the tillage practices, such as scraping, leveling, and deep plowing, which bring large quantities of lime to the surface.

Portneuf silt loam.—Under the virgin cover of sagebrush, Portneuf silt loam is light grayish-brown mellow silt loam to a depth of about 4 inches. Between depths of 4 and 14 inches the material is brown or grayish-brown silt loam, slightly browner and very slightly heavier and firmer than the layer above. When plowed the surface soil is light-brown or grayish-brown silt loam. Neither of these layers contains an appreciable quantity of lime, but they are underlain abruptly at a depth of about 14 inches by very light brownish-gray, yellowish-gray, or nearly white silt loam that has a high concentration of lime and is very compact and brittle when dry. This continues to a depth of about 50 inches. This layer is massive or indistinctly platy and nodular and has cracks, through which roots penetrate. In places the roots are matted horizontally, indicating that, especially at the top, where compaction is greatest, the materials offer some resistance to the penetration of roots. Under irrigation, however, this material softens considerably and probably does not greatly interfere with the penetration of roots. The large yields obtained in this area and in adjoining counties indicate that this layer has little bad effect. The

underlying soil material is very light yellowish-brown or cream-colored very fine sandy loam or silt loam that is soft, floury, and has a uniform color and texture. It continues downward to basalt bedrock.

The depth of this soil is variable, owing largely to the uneven surface of the underlying beds of lava. In some areas the soil is thin and basalt bedrock outcrops in places. In general, however, the mantle of soil material is more than 6 feet thick, and in places it continues to a depth of 20 feet or more.

This soil covers a small total area, most of which is west of Shelley, along the western edge of the area. A small body is southwest of Aberdeen.

The surface ranges from smooth and almost level to gently sloping and undulating, which is ideal for the distribution of water when the land is irrigated. Both surface and internal drainage are good. Much of the excess moisture passes into the underlying fissured lava.

Only about half of this soil is farmed, as it lies too high to be irrigated by gravity flow of water from present diversion points. The water for most of it is brought in by the gravity canals and then elevated by pumping. All the crops common to the area are grown on this soil, but it is devoted chiefly to alfalfa, potatoes, and sugar beets, with some wheat. It produces some of the highest yields obtained, where farmers practice a rotation of 3 or 4 years in alfalfa and an equal number of years in several other crops. In addition some farmers apply triple superphosphate to land for sugar beets and alfalfa with marked benefits. The rate of application is usually from 60 to 100 pounds an acre annually for sugar beets and as much as 200 pounds or more an acre for a planting of alfalfa Available stable manure is used on land for sugar beets and potatoes, and it is very beneficial because of the low organic-matter content of the soil.

Alfalfa produces two large cuttings of hay annually and a smaller third cutting or pasturage, depending on the length of the growing season. Yields range from 4 to 5 tons an acre. Potatoes occupy the second largest acreage and yield 250 to 400 bushels an acre. Sugar beets yield 10 to 18 tons, wheat 35 to 75 bushels (although higher yields are on record), barley 60 to 90 bushels, and oats 60 to 120 bushels.

Flooding and furrow methods of irrigation can be used on this land, because of its favorable relief. On the smoother, flatter areas the border method, in places with furrows, is used for alfalfa and small grains. Intertilled crops, such as potatoes and sugar beets, are irrigated by the furrow method. The furrow method is the most satisfactory on the more sloping areas, as it allows better control and more even spreading of water. Erosion is at a minimum on this smooth land.

Along the western margin of the area west of Shelley and in the vicinity of Lava Side School, several small scattered bodies, totaling about half a square mile, are very fine sandy loam in texture. Small bodies occupying flats or slight depressions have a somewhat heavier texture than is typical, approaching loam or silty clay loam. These included areas do not differ materially in land use or yields from the typical silt loam.

Bodies of included soil on the valley floor, not on the uplands, have developed from fine-textured wind-laid materials over gravelly alluvium. A gravelly substratum underlies the fine material at a depth of 10 to 15 feet in most places, but in a few bodies basalt bedrock apparently is the substratum. The bodies underlain by gravel are small, scattered, and isolated from the typical soil and are intimately associated with soils of the Bannock series. The total area of such inclusions is about 2 square miles. In the virgin state the land is irregular, undulating, rolling, or knoblike; but most of the irrigated areas are smooth, as extensive leveling and grading have been done to make them favorable for irrigation. Underdrainage and the moisture-holding capacity are good. The soil in these areas underlain by gravel is very similar to the typical soil, but in many cultivated areas the calcareous subsoil has been exposed by leveling and the soil has become rather highly calcareous. Because of the treatment given, including applications of manure and some supplementary phosphate, the land is highly productive. The crops grown are the same as those on the typical soil, and yields are very similar.

Portneuf silt loam, rolling phase.—The rolling phase of Portneuf silt loam occupies an area twice the extent of the typical soil. Most of it lies in the northwestern part of the area, west of and near the southwestern edge of Shelley, in the vicinity of Lava Side School, and southwest of Aberdeen. Less than 1 square mile is farmed. Even though the land lies less favorably for irrigation than the typical soil, it would all undoubtedly be farmed if it could be reached by gravity flow of irrigation water. Some of it was dry-farmed for a short time but, because of insufficient moisture, has been abandoned.

This soil has the rolling relief common in soils developed from wind-laid loessial deposits. To a certain extent the lay of the land is influenced by the underlying uneven rolling lava beds.

Because of the uneven relief the surface soil commonly is not so deep as is typical Portneuf silt loam. Rainfall runs off more rapidly, thereby lessening the penetration of moisture and increasing erosion. The depth to the compact limy layer is variable and in many places is less than in the typical soil. The soil profile is intermediate between that of the typical Portneuf and the Wheeler soils. The average depth to lime is about 8 to 10 inches, but in some areas the surface soil is calcareous, especially after cultivation. Such areas have a very light grayish-brown surface soil, owing to the lime, which has been exposed by erosion, or, in many places, by burrowing rodents. There has been some deposition of limy materials in places. In cultivated fields the calcareousness has been increased by leveling and by irrigation.

A few small areas of this soil near the sandier valley floor have a surface soil that is slightly sandier—probably loam.

Irrigation is more difficult than in typical Portneuf silt loam, and penetration of moisture is less effective, but moisture is held well. Crop yields are less uniform and lower than on the typical soil, owing to the thinner surface layers above the lime layer, calcareousness of the soil, and uneven distribution of water. The same crops are grown as on typical Portneuf silt loam. Alfalfa yields 2 to 3½

tons an acre, potatoes 175 to 250 bushels, sugar beets 8 to 12 tons, wheat 25 to 50 bushels, barley 35 to 60 bushels, and oats 40 to 70 bushels. The relief of this soil is similar to that of soils at Springfield, where the slope seems to favor the production of alfalfa seed.

A similar crop rotation including a legume is carried on as on the typical soil. Because of the high lime content of the surface soil, the application of triple superphosphate materially increases yields, especially of alfalfa and sugar beets. More frequent applications than on the typical soil are advisable.

The furrow method of irrigation is the most practical because of the unevenness of the land. Care is necessary to attain an even distribution of water, and smaller heads of water and more careful attention are necessary. Leveling processes have been more extensive on this soil than on the typical soil. Control of erosion is a problem in the more sloping areas.

Portneuf silt loam, steep phase.—The steep phase of Portneuf silt loam occurs mostly in long narrow bodies associated with the areas of Portneuf silt loam west and southwest of Shelley and southwest of Lava Side School. A few small bodies are southwest of Aberdeen. The total area is not large. Practically none of this soil is farmed, even where irrigation water is available, because of its steepness and the fact that most of it lies above the present canals.

The surface soil in most places is only 6 to 8 inches thick, and erosion exposes the grayish-white lime layer in many places, and in many places the small intermittent streams cut through it to the underlying loess and basalt substratum. A few small bodies of steep broken land, which occur along streamways, are included.

Portneuf very fine sandy loam.—The 4-inch surface layer of Portneuf very fine sandy loam in virgin condition is light grayish-brown mellow and friable very fine sandy loam containing an admixture of black particles of basalt. It is underlain to a depth of 16 inches by a more compact layer of somewhat browner loam. Both of these layers are leached of lime. Under cultivation the two layers mix and fields have a dull-brown or light-brown surface soil. The underlying lime layer is light yellowish-gray or yellowish-white compact nodular silt loam. This material grades, at a depth of about 40 inches, into the parent material of very light yellowish-gray loamy fine sand and fine sand, which continues to the underlying basalt. Dark particles of basalt are present in this loose, floury material.

A few small scattered bodies of this soil occur in the uplands southwest of Shelley. The total area is small. A body on the southern margin of the survey joins with a body of Winchester sandy loam of the earlier soil survey of the Portneuf area (7), with which it merges.

The land is smooth and gently sloping to undulating. This soil is developed from a mantle of fine wind-laid material over the underlying lava beds. Both surface and internal drainage are good.

The natural vegetation was sagebrush and rabbitbrush, but most of this soil is now cultivated and produces good yields of all the important crops of the area. It is devoted chiefly to alfalfa, potatoes, and wheat. Yields of alfalfa and potatoes are about the same as or slightly higher than on Portneuf silt loam, but yields of wheat are less. Alfalfa yields 4 to 5½ tons an acre, potatoes 250 to 400 bushels, and wheat 25 to 50 bushels.

Crop rotation, including the growing of alfalfa or clover, is practiced on this soil as on other soils of the area. Deficiencies in organic matter and nitrogen are corrected by such rotation and by the application of available manure. If this treatment is supplemented by the application of superphosphate the yields of alfalfa are materially increased. Deficiency in phosphates is not so marked as in the more limy soils.

Alfalfa and grain are commonly irrigated by the border method and intertilled crops by the furrow method. These methods are effective because of the favorable relief. Erosion is well controlled in most places.

Portneuf very fine sandy loam, rolling phase.—The rolling phase of Portneuf very fine sandy loam occurs as several small bodies in the uplands southwest of Shelley, and there are several north of McDonaldville School. Two bodies are east of Fort Hall.

The relief of this soil generally is strongly rolling, conforming to the surface of the underlying basalt. The soil is shallow in places, especially north of McDonaldville School. Yields are about one-half of those obtained on the typical soil, owing to shallowness and to the uneven relief, which makes even distribution of water difficult. Alfalfa, potatoes, and wheat are grown. Only about half of the total area is farmed.

Portneuf loamy fine sand.—Portneuf loamy fine sand is not essentially different from Portneuf very fine sandy loam, except that the surface soil is loamy fine sand, which, though generally slightly thicker, is more uneven in thickness over the lime layer. This is owing to the light-textured surface soil, which is affected more readily than heavier textured material by leaching and is susceptible to movement by the wind. The subsurface layer is not so marked nor is the lime layer generally so compact as in the very fine sandy loam, because the lime is more evenly distributed to greater depth. Roots perhaps penetrate this layer more readily than in the very fine sandy loam. As mapped, a few small areas of coarser loamy sand are included.

The distribution of the soil is about equally divided between a few scattered bodies southwest of Shelley and west of the Lava Side School and a larger area east of Fort Hall.

The natural relief is undulating to gently sloping, and much scraping has been done to level minor sandy irregularities and to decrease the slope for irrigation. In some leveled areas grayish-white spots of lime mark exposure of the underlying lime layer. Surface run-off is rapid, and internal drainage is good to excessive.

A little more than half of the area is under cultivation; and alfalfa, potatoes, and some small grains are grown. More than half of the cultivated area is devoted to alfalfa. Most of the alfalfa is cut for hay, but seed is also produced with excellent results. Alfalfa yields 4 to 5 tons of hay an acre, or 3 to 12 bushels of seed. Potatoes yield from 175 to 360 bushels and wheat 25 to 40 bushels.

Crop rotation, with alfalfa as the main legume, is practiced on most of this soil. The soil is deficient in organic matter and nitrogen, and it responds markedly to applications of organic manure. More frequent cropping to legumes than on heavier textured soils is essential, in order to increase and maintain the content of organic matter and nitrogen. Application of phosphate, especially on the limy spots

exposed by scraping, is necessary to maintain uniform growth throughout the fields.

Because of its sandiness, the surface soil is especially susceptible to wind erosion, and care must be exercised in cultivation not to accelerate movement of the surface soil. Where proper rotation including a legume is practiced, and especially where barnyard manure is applied, the danger of blowing is reduced materially. Proper moisture conditions for plowing and cultivation are essential to prevent wind erosion. Plowing under green manure and other crop residues is beneficial.

Both the border and furrow methods of irrigation are practiced, depending on the slope. Because of its more droughty character, compared with the very fine sandy loam, this soil requires more frequent irrigation and shorter runs.

As mapped, a few small areas are included with this soil, in which the surface soil is slightly sandier and less loamy than is typical. This inclusion is more droughty than typical Portneuf loamy fine sand, and the surface soil is less resistant to both water and wind erosion. The same crops are grown and the same crop rotation is practiced, but yields are slightly less, owing to the more droughty character and lower fertility of this soil. Greater care must be exercised than on the typical soil to prevent wind erosion.

Portneuf loamy fine sand, rolling phase.—The rolling phase of Portneuf loamy fine sand, an inextensive soil, occupies scattered areas in the uplands southwest of Shelley and north of McDonaldville School. A very small body lies east of Fort Hall. This soil has rather strongly rolling relief, is shallow in spots, and includes a few outcrops of the underlying basalt. It is susceptible to both water and wind erosion, and therefore the depth of the surface soil varies from place to place. For the greater part of its area, however, it has a deep surface soil that is comparatively free of lime.

Less than half of the total area is farmed at present. The land is used principally for the production of alfalfa for hay and seed, potatoes, and some grain. Yields of these crops are about one-fourth to one-third less than on typical Portneuf loamy fine sand.

Even distribution of water in irrigation is difficult because of the rolling relief. The furrow method is used principally, and short runs are necessary because the soil absorbs water rapidly. As this soil is somewhat droughty, frequent irrigation is required. Small heads of water are necessary to prevent erosion.

The difficulties of maintaining fertility necessitate a rigid crop rotation that includes frequent growing of alfalfa or other legumes and application of available organic manures. Careful cultural practices to minimize wind erosion are the same as those on the typical soil.

Ammon silt loam.—Ammon silt loam is, for the most part, cultivated. In virgin areas under a sagebrush cover it is light grayish-brown friable mellow silt loam to a depth of about 3 inches. This layer contains little or no lime. It is underlain to a depth of 12 or 13 inches by light yellowish-brown mildly calcareous firm but friable silt loam. When plowed these two layers are mixed, and the surface soil in cultivated fields is slightly lighter yellowish brown than the virgin soil, is calcareous, and in spots has a high content of lime caused

by exposures of the subsoil after leveling. Lime is also brought in by irrigation waters. Below this and continuing to a depth of about 40 inches is a layer of more highly calcareous very light grayish-brown silt loam, slightly heavier than the layer above. This layer is somewhat compact and contains lime veining and nodules; but the compaction is not nearly so great or the nodules so numerous as in the Portneuf soils. Under the lime layer the material is loose, floury, and light yellowish brown. This material generally is uniform loessial very fine sandy loam or silt loam, but in places thick stratified bands are discernible and a scattering of fine angular gravel is present.

This soil occurs chiefly as a long continuous body north and south of Goshen along the foot of the steep eroded front of the uplands or benchland.

It occupies smooth very gently sloping alluvial fans, which are ideal for distribution of irrigation water. The soil materials are outwash deposits of fine loessial material from the higher uplands occupied by the Wheeler soils. They merge almost imperceptibly with the soils of the valley floor.

Most of this soil is under cultivation. It is considered one of the best soils in the county, from the point of view of fertility, economy of irrigation water, and the lay of the land favorable for irrigation. It compares favorably with Portneuf silt loam in all these respects. It has, however, a higher content of lime in the surface soil and therefore needs more frequent application of phosphate to supplement the rotation with legumes used to increase and maintain the content of organic matter and nitrogen. Crop rotations and the crops grown are, for the most part, about the same as those on Portneuf silt loam. Alfalfa generally occupies the land 3 or 4 years, and potatoes, sugar beets, and small grains follow it for an equal number of years. Where red clover is used in the rotation a 2-year system is practiced. This latter rotation, however, usually is only incidental or temporary and gives way to the more permanent system with alfalfa.

Alfalfa yields from 4 to 5 tons an acre, potatoes 250 to 400 bushels, sugar beets 10 to 18 tons, wheat 35 to 75 bushels, barley 60 to 90 bushels, oats 60 to 120 bushels, and clover seed 3 to 12 bushels. Where field peas are grown they yield from 15 to 45 bushels.

The border method of irrigation for legumes and grains and the furrow method for the intertilled crops are used and are most satisfactory on this smooth, gently sloping land. Bordering the uplands the slope is somewhat greater, and either smaller heads of water should be used or the water should be carried across the slope, in order to irrigate effectively and to prevent erosion. Surface drainage is good, and underdrainage is excellent. The soil absorbs and retains moisture well.

Ammon silt loam, slope phase.—Ammon silt loam, slope phase, occupies a small total area near Lower Presto School, where most of it is farmed. In general the relief is definitely sloping, but in places it is somewhat rolling. This relief has resulted from erosion during the development of the soil, and therefore the surface soil is thin in many places and rather highly calcareous. The more eroded slopes are the more highly calcareous. Although the soil has good moisture-holding

capacity, effective irrigation is more difficult and yields are about one-fourth to one-third smaller and are less uniform than on the typical soil. The crops grown and rotations carried on are the same as on the typical soil.

Because of the high lime content of this soil, crops, especially alfalfa and sugar beets, respond to phosphate fertilization, and crop rotation, including alfalfa or clover, is essential to increase organic matter and nitrogen.

Surface drainage is excessive, and underdrainage is good. Small heads of water are necessary in irrigation, and the furrow method to follow the contour of the land is used, because of the uneven relief. Erosion is difficult to check on the steeper slopes.

Ammon very fine sandy loam.—Ammon very fine sandy loam occupies a small area in association with Ammon silt loam east of Lower Presto School. It is very similar to the latter soil throughout, except for the surface soil of very fine sandy loam. Typically, it has the same gently sloping surface, but a few more sloping and rolling areas are included in mapping. Most of the land is farmed. Crops grown, crop rotations practiced, and yields obtained are about the same as on the silt loam.

Wheeler silt loam.—In its virgin state, Wheeler silt loam has a 3-inch layer of light brownish-gray silt loam containing much very fine sand. This layer contains little or no lime and occurs as soft fragile plates or small slabs over a slightly more compact layer of calcareous silt loam with a high content of very fine sand. This material is slightly yellower than that above. It breaks out in soft clods that are easily crumbled to mellow floury material. The lime layer, which lies between depths of 12 and 40 inches, is very light grayish-brown compact silt loam containing lime veining and a few soft nodules. In most places this lime layer is not nearly so compact or so well developed as in Portneuf silt loam, although in level areas or basins the compaction approaches that of the Portneuf soil. The parent material of uniformly colored light yellowish-brown or light grayish-brown loose floury very fine sandy loam lies about 40 inches below the surface. The mantle of fine soil material generally is thicker than in the Portneuf soils, and many exposures reveal a thickness of 30 feet or more over the underlying basalt, other rock, or, in a few places, stratified old fan deposits.

Several large bodies of this soil lie on the high bench southeast of Goshen. The surface is smooth and undulating to strongly rolling. Most of the land could be irrigated, but, as it lies high above the present canals, none of it is farmed. The Blackfoot River is the only source from which water could be diverted for this soil as well as for other Wheeler soils on this bench. Surface drainage is good, and internal drainage would be excellent under irrigation. The fine loess material has ideal moisture-storage capacity for crop production.

This soil closely resembles Ammon silt loam, and under irrigation it would produce the same crops and similar yields. The grazing value is low, as the vegetation is almost entirely sagebrush.

As mapped, some of the areas are somewhat more strongly rolling than is typical. Here the surface soil above the lime layer is thinner, owing to more active wind and water erosion. Leveling for irrigation would be somewhat more expensive than elsewhere.

Wheeler very fine sandy loam.—Wheeler very fine sandy loam is associated with the other Wheeler soils southeast of Goshen. A small area occurs at the base of Ferry Butte. The 2-inch surface layer is light grayish-brown very fine sandy loam of low plasticity. This material is mildly calcareous. Below this the color of the soil is more yellow or creamy and the material is slightly more compact very fine sandy loam. The material in both layers breaks up readily to a mellow floury condition. The lime layer lies between depths of about 10 and 36 inches. This layer consists of very light brownish-gray, almost white, compact loam or silt loam and contains lime veins and a few rounded lime-cemented nodules. Below it is loose floury light grayish-brown or cream-colored very fine sandy loam, which continues to an undetermined depth.

This soil has its virgin sagebrush cover. It has a rolling to definitely sloping relief, similar to that of Wheeler silt loam, with which it is closely associated. Like that soil, this soil would be difficult to irrigate uniformly, and yields would be less than from more level land. Leveling probably would be expensive. Scraping and leveling would increase the lime content of the soil by exposing the subsoil, thereby further diminishing the yields. A definite system of rotation with legumes and supplementary addition of phosphatic fertilizer would be necessary for satisfactory returns of most crops. Crops and yields would be similar to those of the more rolling areas of Wheeler silt loam.

Wheeler very fine sandy loam, steep phase.—The steep phase of Wheeler very fine sandy loam occurs chiefly on Ferry Butte; other areas are southeast of Goshen and southeast of Shelley. The area southeast of Shelley lies on a small steep-sided butte of basalt, where only a thin mantle of light-textured very fine sandy loam or fine sandy loam covers bedrock. The basalt on Ferry Butte likewise is thinly mantled, especially at the crest. Neither of the buttes can be irrigated, as they lie too high and rise too abruptly from the valley floor. All the land is unsuited for irrigation because of its steepness. It is severely eroded in spots, being denuded of surface soil and cut by deep gullies. The surface soil is thin and calcareous, and exposures of the underlying lime layer are common. The profile of the soil varies considerably from place to place.

SOILS OF THE TERRACES OR VALLEY FLOOR

The soils of the terraces or valley floor (fig. 2, 2–6) cover more than three-fourths of the area surveyed. These soils are developed largely from old stream-laid and lake-laid deposits, with some admixture of loess and other wind-transported materials, especially in the surface soils. In certain localities wind has sorted and shifted the loose surface material, producing a hummocky and dunelike relief. The valley floor generally is smooth and slopes gently with the gradient of the river, although it consists of a succession of long, comparatively narrow terraces, separated from the river bottom by definite bluffs.

Like the soils of the uplands, the soils of the terraces have light-brown or light grayish-brown surface soils. They have, however, a wide range of soil characteristics and suitability for use. They range in texture from silty clay loam to sand, and soils on the gravelly ter-

races contain gravel, which in most places does not prohibit cultivation but reduces the water-holding capacity and to some extent the fertility of the soil. Some of the soils are so sandy as to be of very little value for agriculture. Mineral fertility is inherently high in most of the soils, but organic matter and nitrogen are deficient. The more calcareous soils of the group become low in available phosphate after a period of cultivation and irrigation. Surface soils are made more limy by scraping, leveling, and irrigating. With proper crop rotation, including alfalfa or some other legume, incorporation of organic farm manures and crop residues, and application of phosphate where needed, most of these soils can be built up and maintained in a high state of fertility.

The outstanding differences in the soils of the terraces or valley floor result largely from the texture of the parent materials and of the underlying materials, which considerably modify their moisture-holding capacity, permeability, and drainage. The soils from deep deposits of fine silty and clayey materials have high water-holding capacity and high productivity; the fine-textured soils over gravel have somewhat lower water-holding capacity and about the same or slightly lower productivity; whereas the very gravelly and sandy soils are droughty and hard to handle and have comparatively low productivity and generally are poorly suited to cultivation.

The soils underlain to considerable depth by stratified silts and clays include those of the Sagemoor, Declo, and Fingal series. The Fingal soils have gravelly substrata in places; the Paul and Bannock soils have a moderate depth of comparatively fine materials over beds of gravel and sand; and the soils of the Rupert and Winchester series generally are sandy and porous throughout, although the Winchester soils in some places lie over basalt bedrock.

The Sagemoor soils occur on old lake terraces, are developed from fine silty and clayey lake-laid materials, and are characterized by compact limy subsoils that are slowly permeable to moisture. These soils are somewhat similar to the Portneuf soils except for the heavier and more compact character of the subsoils and substrata. They have light grayish-brown noncalcareous surface soils, subsurface layers that are noncalcareous, somewhat heavier, more compact, and browner, and compact limy subsoils. In spite of the compact subsoils, drainage is adequate in most places, and the soils are highly productive and largely under cultivation.

The Declo soils are similar to the Sagemoor, but have somewhat more calcareous surface soils and less compact subsoils. They are well drained for the most part, although some areas are subject to a high water table caused by seepage of irrigation water. Most of the areas are farmed and are highly productive.

The Fingal soils are dominantly poorly drained. They have slightly darker surface soils than the Sagemoor and Declo soils and contain considerable pepper-and-salt (basalt and quartz) sand. They have tough heavy subsoils with less concentration of lime than in the Sagemoor and Declo soils. Drainage and the concentration of salts have become worse under irrigation, and most areas of these soils are not cultivated.

The Bannock soils are light grayish-brown soils over light-gray rather compact limy subsoils. They resemble the Portneuf and

Declo soils in the upper layers but are somewhat gravelly and overlie beds of gravel and sand. Drainage is good or excessive, and the productivity ranges from medium to very high.

The Paul soils have developed on fine-textured alluvial materials overlying beds of gravel and sand, which commonly are several feet below the surface. The soils are somewhat similar to the Bannock soils but are slightly darker and browner and dominantly are somewhat finer and deeper to gravel. They are also somewhat similar in their upper layers to the Sagemoor, Declo, Portneuf, and other soils of the uplands and terraces. The surface soils are brown and noncalcareous, the upper subsoil layers are slightly richer brown, heavier, and more compact, and the lower subsoil layers are compact, light gray, and highly calcareous. These soils are largely under cultivation and are highly productive. The sand member is only moderately productive.

The Rupert soils are porous sandy soils that contain little or no lime to a depth of 30 inches. The lower subsoil layer and substratum contain some lime, but in few places is it heavily concentrated, and the soil material is loose and porous. These soils are excessively drained and have a low water-holding capacity. Only a small part of them is farmed, and they have low productivity for most crops. Alfalfa seed, the most important crop, yields fairly well.

The Winchester soils are loose sandy soils subject to drifting by wind. They have very little development of a profile and have a pepper-and-salt appearance caused by the presence of black basaltic and white quartz sand. They are too loose, porous, and easily shifted by wind to be farmed successfully.

Sagemoor silt loam.—The 4-inch surface layer of Sagemoor silt loam in virgin condition is light grayish-brown friable silt loam, in places containing a high proportion of very fine sand. It is underlain to a depth of 12 inches by light-brown heavier silt loam or silty clay loam of rather cloddy compact structure. In plowed fields the materials in these two layers mix, and the surface soil has a richer brown color and a heavier silt loam texture. The above layers contain little or no lime. Between depths of about 12 and 46 inches is the compact lime layer, which has a platy structure at the top and is more nodular toward the bottom. Rusty-iron stains and matted roots are present in both vertical and horizontal cracks. This material rests on thick strata of light brownish-gray or greenish-gray silty, clayey, and sandy materials. These strata, with textural differences and color variations including light yellow and buff, continue to an undetermined depth. In most places small shells and fragments of shells are present.

This soil covers a fairly large total area. Bodies are scattered throughout the Grandview-Pingree terrace, the largest lying west of Moreland. Most of the land is farmed.

The surface is smooth and level to undulating. This soil was readily put under irrigation, because of the smooth surface, and even distribution of water is obtained with a minimum amount of labor. The border method of irrigation is used for hay and grains and the furrow method for intertilled crops. Surface drainage is good, and internal drainage is adequate, despite the underlying lake-laid strata of silt and clay. West of Moreland the clay strata are not so clearly

defined as elsewhere, and here the material may be of lake delta origin. It is probable that the surface soils consist partly of fine floury wind-borne materials.

All crops common to the area are grown on this soil, but the chief crops are alfalfa hay and seed, small grains, potatoes, and, to a less extent, sugar beets. The more isolated areas are used mainly for alfalfa (for hay) and small grains, and the areas in the vicinity of Springfield are used mainly for alfalfa seed. This soil compares favorably with Portneuf silt loam in yields of all crops except potatoes and sugar beets. These crops make smaller returns than on the Portneuf soils, probably because the surface soil is thinner and the more compact lime layer seems to retard the penetration of roots into the deeper subsoil. Alfalfa yields 3½ to 5 tons of hay or 6 to 15 bushels of seed an acre. Wheat yields range from 35 to 80 bushels, barley 60 to 90 bushels, and oats 60 to 120 bushels. Probably about 80 percent of the cultivated area is used to produce the above-mentioned crops. Potatoes yield 220 to 325 bushels an acre, and sugar beets 8 to 15 tons. A small acreage is devoted to clover seed, which yields from 3 to 12 bushels an acre. Peas, grown occasionally, return 15 to 40 bushels.

The Grimm variety of alfalfa is commonly preferred on this soil. It has a lateral root system, which forms largely above the compact subsoil, whereas penetration by the taproot of the Common variety of alfalfa may be seriously retarded. Common alfalfa, however, does penetrate the lime layer to some extent, making it more permeable to succeeding crops and to irrigation water. Where a proper rotation including alfalfa is carried on, the soil is in a good state of fertility. The original surface soil was not calcareous, and phosphate fertilizer is not so essential as on the more limy soils. Some spots of shallow soil that occur naturally or have developed in leveling would benefit by the application of phosphate fertilizer. On the whole, because of the favorable relief, erosion is not a serious problem.

Sagemoor silt loam, slope phase.—Bodies of the slope phase of Sagemoor silt loam are scattered throughout the Grandview-Pingree terrace. It has a sloping to rolling relief somewhat resembling that of the Portneuf soils. Areas of this soil are closely associated with scattered areas of bedrock and scabland and with stony areas of basalt boulders overlying the lake-laid clays. Bedrock has retarded deeper erosion, and the basalt boulders have served as a protective covering. The resultant relief is characterized by rolling knobs and ridges underlain by the uneven lava beds or capped by huge basalt boulders that probably were transported by floating ice.

This soil differs from the typical Sagemoor silt loam in its sloping to rolling relief and thinness of the surface soil. In many places the lime content is high and grayish-white spots of lime have been exposed by erosion and leveling.

About 75 percent of this soil is farmed. All the crops grown on the typical soil are grown on this sloping land, because of its close association with that soil, but alfalfa and small grains are considered the best adapted crops. Large areas are used for the production of alfalfa seed, especially near Springfield. The thin surface soil and the fact that the soil can be kept fairly dry both prevent too heavy vegetative

growth, which seems detrimental to the satisfactory development of seed. Alfalfa yields 2 to 4 tons of hay or 5 to 12 bushels of seed an acre. Wheat yields 25 to 60 bushels, barley 35 to 65 bushels, and oats 35 to 70 bushels. Potatoes, where they are grown, yield from 125 to 250 bushels, and sugar beets 5 to 10 tons. Yields of clover seed are about the same as for alfalfa.

Crop rotation, including the growing of alfalfa or other legumes, as practiced on the typical soil is necessary to increase and maintain the organic matter and nitrogen, which are deficient. Because of the higher lime content of the surface soil it is often necessary to make heavier and more frequent application of phosphate fertilizers.

Surface run-off is rapid, and internal drainage is sufficient, so that no seepage or salt accumulations have developed. Despite the sloping relief, the soil absorbs and retains moisture well. Distribution of water is more difficult than on smoother, more level land, and considerable loss may occur because of the more rapid run-off. The furrow method of irrigation is usually practiced because of the slope. Small heads of water and careful control are necessary to prevent erosion, as the surface soil and underlying lake clays are very erodible.

Sagemoor silt loam, shallow phase.—The shallow phase of Sagemoor silt loam is not very extensive. Most of it occurs as small scattered areas near the bordering lava beds west of Moreland and southwest of Grandview. Less than half of the land is farmed.

In general, the surface is sloping to rolling, conforming to the uneven surface of the underlying lava beds. The soil materials are thin over these beds, and the soil profile is extremely variable. Outcrops of lava bedrock are common, and the surface soil in many places contains basalt stone and fragments, which are generally lime coated. Most of the areas are eroded, and the thin surface soil is generally limy. In many places lime fragments from the subsoil are scattered throughout the surface soil.

Most of this soil is devoted to alfalfa and small grains because of the thin limy surface soil and because the areas are isolated from marketing centers. Alfalfa yields about 2 to 3 tons an acre of hay or 3 to 7 bushels of seed. Wheat yields 10 to 35 bushels, barley 15 to 35 bushels, and oats 15 to 40 bushels. Potatoes and other subsistence crops are grown, but yields are small. Strict adherence to a rotation including a legume is necessary for satisfactory yields. Barnyard manure and crop residues are very beneficial to the land. An application of phosphate to the land for alfalfa would increase the yields materially because of the high lime content of the soil.

Careful irrigation with small heads of water is necessary for proper saturation of the soil and to prevent erosion.

Sagemoor very fine sandy loam.—In virgin areas the 4- or 5-inch surface layer of Sagemoor very fine sandy loam is light-brown friable and mellow very fine sandy loam. Below this and continuing to a depth of about 14 inches is a subsurface layer of light-brown or medium-brown silt loam or silty clay loam that is compact and breaks into clods. In plowed fields the subsurface soil is brought to the surface, giving the surface soil a browner color. These two layers are not limy in the virgin condition. The light yellowish-gray or almost white layer of lime concentration lies between depths of 14 and 40 inches. This material is compact and brittle, breaking into angular fragments

at the top, and it is nodular below. Root fibers and rusty-iron staining occur in the cracks. Below this are thick strata of light grayish-brown silty clay loam that have a somewhat yellowish to greenish hue. Thick strata of yellow or buff clay and sand are at a greater depth, generally below 8 feet.

Small scattered bodies of this soil occur on the high terrace occupied by the Sagemoor soils in the southwestern part of the area. The land is smooth and level to undulating. Surface drainage is good, and no seepage or extensive accumulations of salts have developed, indicating good internal drainage. The moisture-holding properties are very good.

Most of this soil is farmed. In the vicinity of Grandview it is devoted mainly to the production of alfalfa seed, but elsewhere it is used for all the crops commonly grown. Its productivity is about the same as that of Sagemoor silt loam. Alfalfa yields about 3½ to 5 tons of hay an acre or 6 to 15 bushels of seed. Wheat yields 30 to 70 bushels, barley 50 to 80 bushels, oats 50 to 100 bushels, potatoes, 250 to 350 bushels, and beets 8 to 15 tons. Clover seed yields about the same as alfalfa seed.

As on the other Sagemoor soils, the Grimm variety of alfalfa is preferred for this soil, because the seed commands a higher market price than seed of the Common variety, and the shallow lateral root system seems adapted to these soils. When proper rotation including legumes is carried on, this soil is brought to a satisfactory state of productivity. Barnyard manure and phosphate increase the productivity, especially on the more limy or shallow soils.

The border method is used in irrigating alfalfa and small grains, and the furrow method is used for intertilled crops. The smooth surface of this soil is favorable for uniform distribution of irrigation water. Erosion is negligible.

Sagemoor very fine sandy loam, slope phase.—The slope phase of Sagemoor very fine sandy loam is similar to the slope phase of Sagemoor silt loam in soil characteristics and in relief. The relief is sloping to rolling, conforming to the surface of the underlying lava beds and influenced by stony areas of boulder-capped clays. The surface soil is thinner than in the typical soil, and in many places it is calcareous, owing to removal of the leached surface soil by erosion and by leveling of the land for irrigation.

This soil occurs on the upper Grandview-Pingree terrace, from the vicinity of Grandview northeastward, and in the vicinities of Springfield and Aberdeen. The total area is small, and most of the land is farmed.

The larger part of this soil is used for the production of alfalfa seed. Both the slope of the land and texture of the soil favor this crop. Most of the crops of the area are, however, grown to some extent. Alfalfa produces 2 to 4½ tons an acre of hay or 6 to 15 bushels of seed. Clover produces about the same quantity of seed as alfalfa. Wheat produces 20 to 55 bushels, potatoes 175 to 300 bushels, and sugar beets 5 to 10 tons. Where seed is produced, the soil is brought to a good state of fertility by growing legumes. In other areas a crop rotation including legumes, similar to that on the other soils of the area, is followed. Applications of manure and

other organic residues and phosphate, especially to the spots of shallower and limier soils, are essential for uniform yields.

The furrow method of irrigation with small heads of water is the most satisfactory. This prevents excessive erosion, to which this soil is subject because of the slope.

Sagemoor very fine sandy loam, shallow phase.—The small bodies of the shallow phase of Sagemoor very fine sandy loam cover a small total area. The soil material is shallow over the uneven underlying lava beds, and the relief in general is rolling. The surface soil is thin and generally highly calcareous. The limy subsoil is compact and in many places directly overlies the basalt. Stone and basalt fragments are common throughout the soil, and lava outcrops in many places. Most of the stone and smaller basalt fragments are lime coated, and lime fragments are scattered throughout the surface soil.

Only about one-half of this soil is farmed. The uneven relief and the shallow soil containing a few stones make cultivation and irrigation difficult, and yields are small. The same crops are grown and similar yields are obtained as on the shallow phase of Sagemoor silt loam.

A definite rotation, including alfalfa or other legumes, and the incorporation of all organic manures available should be practiced on this soil in order to increase production. Phosphate is an essential fertilizer, especially for alfalfa.

The furrow method of irrigation with small heads of water is the common practice. This insures better distribution of water and saturation of the soil and reduces erosion. Frequent application of water is necessary because of the thin soil, which in most places does not exceed 3 feet in depth.

A long narrow area of steeper than average relief lies along the terrace front near Grandview, and several others occur north and west of Moreland. The slopes are not so steep or so broken as those of rough broken land. They have a more uniform although very thin soil cover. Sheet erosion has exposed many almost white spots of the underlying limy subsoil, and many small gullies have cut through the subsoil to the underlying strata. Where farmed these steeper areas are difficult to irrigate successfully. They are seldom used for crops other than alfalfa hay and seed, and generally are used only for pasture. Hay yields are small, but fair success may be had in growing seed.

Sagemoor silty clay loam.—In virgin condition, Sagemoor silty clay loam has a 4- or 5-inch surface layer of grayish-brown or dull medium-brown heavy silt loam or silty clay loam that is friable when dry but plastic when wet. This is underlain to a depth of 16 inches by a slightly richer medium brown more compact silty clay loam subsurface layer. The material breaks into angular aggregates. Both layers contain little or no lime. In plowed fields the subsurface soil mixes with the surface layer, making the color somewhat browner and the texture slightly heavier. The lime layer between depths of 16 and 50 inches is very compact very light gray or yellowish-white material with rusty-iron staining along cracks. It is very compact in the upper part, but in the lower part it is more friable and contains

nodules and veins of accumulated lime. This rests on light greenish-gray or brownish-gray thick-bedded mottled clay and sand strata. Below a depth of 7 to 8 feet it is bedded light yellowish-gray or buff clay that is more massive than the clay above. Shells are present throughout.

This soil is about as extensive as Sagemoor silt loam and is distributed as widely over the Grandview-Pingree terrace. It is an important agricultural soil, and most of it is farmed.

Characteristically, this soil occupies low positions where it has received run-off from higher lying land; therefore it is more deeply leached and has a higher organic matter content than the other Sagemoor soils. In many places it adjoins the uplands. There are, however, inclusions of soil that are less flat than the typical soil. Here the surface soil is thinner, lighter colored, and in many places light gray on account of lime. Similar inclusions represent areas where leveling for irrigation has been carried on in order to remove small irregularities. Even though the land is flat to gently sloping, surface waters move freely to drainageways and the soil is well drained. Underground drainage is sufficient in most places, and little evidence of poor drainage exists. The moisture-holding capacity is very good. A few small areas west of Springfield are affected by irrigation seepage and concentrations of salts.

All the crops common to the area are grown on this soil with excellent results. The favorable structure and the deep noncalcareous surface soil probably contribute to make this soil highly productive for all crops, even though the heavy texture is not the most favorable for such crops as alfalfa and potatoes. Potatoes often produce less smooth tubers and a smaller proportion of marketable grades than on lighter textured soils. The compact limy subsoil apparently softens under irrigation, as there seems to be no serious impediment to the penetration of roots or water. Grimm alfalfa is preferred for this soil, although Common alfalfa might prove superior on account of its ability to penetrate the compact lime layer, thus making it more penetrable to succeeding crops. The Common variety, however, is more susceptible to winter-killing because of the taproot, and on low flats damage would be high in wet years.

More than half of this soil is devoted to alfalfa. Although not so good a soil for the production of seed as sandier and more sloping soils, a considerable acreage is used for this purpose in favorable years. Alfalfa yields 3 to 5 tons of hay or 4 to 10 bushels of seed an acre. Wheat is grown on about one-fourth of the land, which is very favorable for the production of this crop, and yields of 40 to 85 bushels are obtained. Barley and oats occupy a smaller acreage and yield 65 to 95 bushels and 60 to 120 bushels, respectively. Both potatoes and sugar beets are grown as cash crops. Potatoes yield 220 to 325 bushels an acre and sugar beets 8 to 19 tons. A small acreage is devoted to clover for seed, with yields of 5 to 15 bushels an acre. Peas and beans, occasional crops, yield 20 to 45 bushels and 10 to 30 bushels, respectively.

This soil is very easily irrigated, as its smoothness aids the distribution and absorption of water. The border method of irrigation for legumes and grain and the furrow method for intertilled crops are very satisfactory. Excess water usually runs off readily, but the re-

moval of accumulations of water from the surface sometimes requires open ditches.

A fairly efficient crop rotation, including alfalfa or other legumes, is usually followed, legume crops occupying the land about half of the time. Phosphate is not so essential as on the more highly calcareous soils, but limy spots should be treated in order to promote more uniform growth. Although this soil is not so deficient in organic matter as other members of this series, organic manures should be used in order to maintain fertility and good tilth in so heavy textured a soil.

Sagemoor silty clay loam, slope phase.—The slope phase of Sagemoor silty clay loam covers a small total area. It is widely distributed as small bodies in association with bodies of the typical soil. Unlike that soil, it has a thin surface soil, and exposures of the limy light-gray subsoil are common. The relief is definitely sloping to rolling. Irrigation is more difficult, and erosion is harder to control than on the typical soil. This soil most closely resembles the slope phase of Sagemoor silt loam in soil characteristics and in relief. About the same crops are grown, and similar yields are obtained on the two soils.

Sagemoor fine sandy loam.—The 5-inch surface layer of virgin Sagemoor fine sandy loam is light-brown mellow friable fine sandy loam. It is underlain to a depth of 14 inches by slightly richer brown loam. This material is compact and cloddy. Both these layers are leached of lime where undisturbed. When plowed, the surface soil becomes slightly browner and heavier because the two layers mix. The compact lime layer of yellowish-white silty clay loam very abruptly underlies these two layers and is about 30 inches thick. The material breaks into angular fragments at the top and is less compact and contains more lime nodules and veins below. Rusty-brown iron cementation is interspersed with the lime in the more compact zone. Roots appear to penetrate this layer with difficulty, in many places spreading horizontally along cracks in flattened masses. Below a depth of about 44 inches greenish-drab puttylike clay strata are interbedded with thin sandy lenses. Small shells are present but are not so numerous as in the deeper clays and sand, which lie 10 to 12 feet below the surface.

This soil occurs in the vicinities of Grandview and Springfield and north of Pingree. The total area is small. Most of the land is farmed.

The land is smooth and level to undulating. Surface drainage is good, and internal drainage is usually good because of the high position, although a few areas west of Springfield lie close to poorly drained and alkali-affected soils.

Probably about two-thirds of the total area is used for alfalfa hay and seed. Small grains and, in some districts, potatoes and some sugar beets, are also grown. Most of the alfalfa in the vicinity of Grandview and Springfield is grown for seed. Alfalfa yields from 4 to 5 tons of hay or 8 to 18 bushels of seed an acre, wheat 25 to 65 bushels, barley 35 to 75 bushels, oats 40 to 80 bushels, potatoes 250 to 350 bushels, and sugar beets 8 to 15 tons.

This soil is deficient in organic matter and nitrogen, and crop rotation including the growth of alfalfa or other legumes and the incorporation of farm manures and organic residues is essential for satis-

factory continuous yields. In most places the soil is well leached of lime, and phosphate fertilization appears to be necessary only on those spots that have become calcareous through leveling for irrigation. This soil is more favorable for the production of alfalfa and potatoes than other soils of this series.

The lay of the land is favorable for efficient distribution of irrigation water. The soil absorbs water readily and holds it well. The border method of irrigation is usually employed for hay and grain crops and the furrow method for intertilled crops. In production of alfalfa seed, furrows are used in many places, in addition to the borders.

Sagemoor fine sandy loam, slope phase.—The slope phase of Sagemoor fine sandy loam covers a small total area and is widely distributed in small bodies, mostly near Springfield. It has a sloping to rolling relief, principally developed through water erosion, although many minor irregularities result from action of the wind. The depth of the surface soil is variable, but in most places this layer is thin. In general, this soil is not so calcareous as other slope phases of the Sagemoor soils, as much of the surface material is probably derived from noncalcareous wind-blown sand superimposed over the eroded lake clays. Leveling for irrigation, however, has exposed spots of almost white limy subsoil. Although it lies nearer the surface, the lime layer generally is not so compact as in typical Sagemoor fine sandy loam.

This soil is used principally for the production of alfalfa seed. Both the soil and the slope are favorable for its production. Yields of 6 to 15 bushels an acre are obtained. Potatoes and small grains most commonly follow this crop.

The furrow method of irrigation must be used for satisfactory distribution of irrigation water, owing to the slope of the land. Because of the light texture of the soil, more frequent irrigations are usually necessary than on other slope phases of this series. Small heads of water are necessary to check erosion and to obtain more complete saturation.

Because of the long periods that alfalfa occupies the ground in the production of seed, fertility is maintained without resorting to other soil-building processes. The more calcareous areas would profit by the absorption of phosphate.

Sagemoor fine sandy loam, shallow phase.—Only a small total area of Sagemoor fine sandy loam, shallow phase, is mapped. It is widely distributed as small bodies north of Pingree and from a point west of Springfield to the vicinity of Grandview. In many places the surface is sloping, as the uneven lava beds and masses of boulders massed in the soil have resisted erosion. The soil cover is thin, in most places less than 4 feet deep, and is interrupted by numerous outcrops. The surface soil is generally calcareous, and fragments of the underlying lime layer are scattered throughout. Lime-coated stone and fragments of basalt are common.

About one-half of this soil is farmed. It is used mainly for the production of alfalfa hay, alfalfa seed, and small grains. The shallow soil, stone content here and there, and rock outcrops make it less suitable than the typical soil for intertilled cash crops. Alfalfa yields from 2 to 3 tons of hay an acre or 3 to 8 bushels of

seed and wheat 10 to 30 bushels. Yields of other small grains are low.

Both the border and furrow methods of irrigation are used, depending on the slope. Frequent irrigations are necessary to assure satisfactory yields. Careful irrigation is essential for proper saturation and for prevention of erosion on the more sloping areas.

Sagemoor fine sandy loam, steep phase.—The steep phase of Sagemoor fine sandy loam occurs as scattered bodies along the terrace fronts and along drainageways between Springfield and Grandview. The total area is small, and because of its steepness only a small part of the land is farmed. The slopes are steep but not broken, although they are cut by small gullies and sheet erosion is active. The surface soil is very thin and uneven over the unevenly developed lime layer, and in places the underlying clay strata are exposed at the surface. This surface soil is highly calcareous, and almost white lime exposures are common. On the whole, this soil is well drained even though it lies in close proximity to lower lying areas affected by seepage and salts. A few low-lying areas are affected by seepage that follows the underlying clay strata.

Alfalfa for hay and seed is the principal crop plant. Most of it is cut for seed, which yields 3 to 8 bushels an acre. Some of it is used for domestic pasture.

These steep areas underlain by clay strata are very susceptible to erosion, and it is essential to have a satisfactory vegetative cover in order to protect the soil. Alfalfa checks erosion to some extent, but pasture grasses would be more satisfactory. The furrow type of irrigation is the most satisfactory, and small heads of water must be used to give sufficient penetration and to keep erosion at a minimum. More frequent irrigations are necessary than on the typical soil.

Declo loam.—To a depth of about 12 to 14 inches Declo loam is medium-brown to light-brown mellow and friable loam that is noncalcareous or mildly calcareous. The virgin soil has a dull grayish-brown surface layer a few inches thick. The cultivated soil generally becomes calcareous through influence of irrigation water or through leveling that exposes the limy subsoil. It is underlain to a depth of 40 inches by the lime layer of very light gray or slightly brownish-gray silt loam or silty clay loam. The upper part of the layer, a few inches thick, breaks into horizontal plates, whereas the lower part is more friable and contains spherical lime nodules and lime veins. This material crumbles readily and offers little resistance to the penetration of roots and water. Below a depth of about 40 inches are stratified light brownish-gray materials consisting largely of very fine sandy loam and fine sandy loam, with very fine sand and fine sand in places. These friable materials continue to the basalt bedrock, which generally lies 6 feet or slightly less below the surface. Fragmentary materials and water-worn quartzite gravel and sand are generally sprinkled over the basalt floor. A few pebbles occur in the soil material.

Within the Aberdeen town site and within about half a mile of the outer boundary of the area, clay strata directly underlie the lime layer. These restrict the movement of water somewhat, and traces

of salts have developed in places. Clay strata, generally at a greater depth, also impede the free movement of water east of the drain beginning 2 miles south of the town. Salt-affected areas have developed, and water seeps horizontally to the drain and reservoir.

Most of this soil lies in the immediate vicinity of Aberdeen, and small bodies are widely scattered over the Aberdeen terrace.

The surface of this soil is flat to slightly undulating, conforming to the uneroded surface of the remarkably flat Aberdeen terrace. Over most of the area, surface water moves off freely. Internal drainage has been sufficient in the past on most of the soil, even though drainageways are few and not deeply incised in the back terrace; but internal drainage is now being retarded by the underlying clay strata and by seepage from the higher parts of the Grandview-Pingree terrace. Although most of this soil is fairly well drained and free from salts, it is contiguous to areas that are affected by seepage and accumulations of salt.

Agriculture on this soil is highly diversified, and all the crops common to the area are grown. All the land is farmed. Alfalfa occupies more than half of the land, in rotation with cash crops. Wheat, used most extensively as a nurse crop in replanting to alfalfa, probably occupies one-fourth of the land. Potatoes cover the next largest acreage. Other crops in order of importance are sugar beets, barley, oats, peas, clover seed, and beans.

Alfalfa yields are high, 4 to 5 tons of hay an acre usually being obtained. Alfalfa seed is grown to a small extent and yields 5 to 12 bushels. Wheat yields 35 to 75 bushels, barley 55 to 85 bushels. and oats 50 to 100 bushels. Potatoes are grown very successfully on this soil and yield 250 to 400 bushels. Sugar beets yield 10 to 18 tons an acre, peas 15 to 40 bushels, beans 10 to 30 bushels, and clover seed 5 to 12 bushels.

In common with the other soils of the area, this soil is deficient in organic matter and nitrogen. The common crop rotation, in which alfalfa or other legumes occupy the land for 3 or 4 years and cash crops an equal number of years, helps to maintain the soil in a high state of productivity. Marked increases are obtained, however, where barnyard manure and crop residues are used. The use of phosphate fertilizer is becoming necessary, especially for alfalfa and sugar beets, because of the lime content, which increases yearly through irrigation and leveling. Because of the favorable smooth surface, the border method for irrigation of alfalfa and small grains and the furrow method for intertilled crops such as potatoes and sugar beets are the most satisfactory. This soil absorbs water readily and has excellent water-storage capacity. Erosion is not a problem, because of the smooth lay of the land.

Declo loam, slope phase.—The slope phase of Declo loam is widely distributed in small bodies, chiefly south of Aberdeen, and the total area is small. The sloping to rolling surface is less favorable for irrigation than that of the typical soil. The surface soil is thinner than in Declo loam and generally is definitely calcareous. Most of this soil is well drained, although seepage is encroaching in some places and salts have accumulated. Like the typical soil, this soil occurs in close association with salt-affected areas and is in danger if seepage increases and spreads.

This soil is used for the same crops as the typical soil, but, because of the thinner surface soil and steeper slope, yields are somewhat less. Alfalfa yields 3 to 4 tons of hay an acre, and yields of seed are about the same as on the typical soil. Wheat yields 25 to 60 bushels, and potatoes 220 to 325 bushels. Yields of other crops are proportionately low.

The furrow method of irrigation is the most satisfactory because of the slope of the land. Small heads of water are necessary for satisfactory saturation of the soil, without excessive loss of water, and for the prevention of erosion.

Declo loam, steep phase.—The steep phase of Declo loam, an inextensive and mainly nonagricultural soil, consists of an almost continuous long narrow bluff along the drainageway at Aberdeen and southward to the reservoir, where it follows the bluff overlooking that basin. The underlying lake-laid strata are exposed in many places on the steep bluffs. Lateral gullies are invading the terrace so that only remnants of the original surface soil remain, and these in many places are subject to sheet erosion. The texture of the surface soil ranges from silty clay loam to very fine sandy loam, although loam predominates. Along the draw beginning 2 miles south of Aberdeen are a few less steep and less eroded areas, on which some cultivation is practiced. These are used mostly for alfalfa hay and seed and some pasture. Seepage waters usually issue from the clay strata, and salts are generally present, especially at the base of the escarpment.

Declo silty clay loam.—The 12-inch surface soil of Declo silty clay loam is medium-brown to light grayish-brown silt loam or silty clay loam that is mellow and friable when dry but sticky when wet. Plowed fields are generally somewhat browner and slightly heavier in the surface soil than virgin areas. In most virgin areas the surface soil is leached of lime, but under irrigation it becomes more or less calcareous. The layer of lime accumulation abruptly underlies the surface soil and continues to a depth of about 44 inches. It consists of very light-gray or very light brownish-gray silty clay loam. The upper 4 or 5 inches of this material are somewhat platy and compact, but the material below is more friable, contains veins of accumulated lime along fractures, and includes soft spherical nodules. This is underlain by stratified fine sandy loam and loam that is light grayish brown in the upper part and more yellow and buff below. This stratified material continues to the underlying basalt bedrock.

Soil areas lying within about half a mile of the outer boundary of the Aberdeen town site have more clayey strata directly underlying the lime layer, and the surface soil in many places is thinner and more calcareous than in typical Declo silty clay loam. The underlying strata in many places are comparatively high in salts, and gypsum crystals can be identified in places. Internal movement of water through this clay is slow, and care should be exercised in the disposal of excess water from irrigation. Soils immediately east of the draw 2 miles south of Aberdeen also are underlain by thick-bedded clay strata, which retard downward percolation of water.

The larger bodies of this soil lie directly south of Aberdeen, but some smaller ones are scattered over the Aberdeen terrace. Practically all of the land is farmed.

The land is comparatively smooth and flat to gently undulating, and so is excellent for economical distribution of water. Although the surface is flatter than that of most of the soils of this series, surface drainage is nearly everywhere sufficient to carry off the excess surface water when care is exercised in irrigation. Sometimes open surface ditches are used. Internal drainage is favorable except in those areas underlain by heavy clay strata, described above. Careful control of irrigation water is necessary in these areas in order to minimize seepage and prevent salty (alkali) areas from enlarging. The soil has good moisture-holding capacity, and the surface soil has a favorable structure in spite of its heavy texture. The border method of irrigation for hay and grains and the furrow method for intertilled crops give good results on this soil. Because of the smooth lay of the land, erosion is not a problem.

The acreages devoted to various crops and yields are about the same as on Declo loam. Alfalfa yields from 3½ to 5 tons of hay an acre, but very little seed is grown. Wheat yields 35 to 85 bushels, barley 60 to 95 bushels, and oats 60 to 120 bushels. Potatoes are an important cash crop, and yields of 220 to 350 bushels are obtained. Sugar beets produce from 8 to 18 tons. Peas yield 15 to 45 bushels and beans 7 to 25 bushels. Clover seed usually produces from 4 to 10 bushels.

Like the other soils of the area, this soil lacks organic matter and nitrogen and is improved with a rotation including alfalfa or other legumes, such as is carried on for Declo loam. Noteworthy increases in yields are obtained where barnyard manure is also applied. Although this soil is not generally highly calcareous, a few limy spots resulting from scraping in leveling would benefit from phosphate fertilization, especially for the production of alfalfa and sugar beets.

As mapped this soil includes an area of about 1 square mile southwest of Aberdeen that has a somewhat thicker surface soil than is typical. This included area is nearly flat and shows evidence, in depth of leaching and organic-matter content, of having supported a more luxuriant vegetation in its virgin state. The surface soil is richer brown than the typical soil and generally 16 to 18 inches thick. It is leached of lime and has excellent structure, so that productivity is high, exceeding that of the typical soil. A definite crop rotation including legumes is followed, and supplementary barnyard manure is applied. Irrigation water can be efficiently applied. Both surface and internal drainage are sufficient.

Declo silty clay loam, slope phase.—The slope phase of Declo silty clay loam occurs mainly south of Aberdeen in small widely scattered bodies. The total area is about 1 square mile. The surface is sloping to somewhat rolling. The surface soil is thinner and generally grayer and more calcareous than in the typical soil. Some of the areas near the county line have a shallow soil broken here and there by outcrops of the underlying lava beds. This soil has the same variations of the clayey strata in the subsoil and substratum as described for the typical soil. In these positions a few areas are affected by seepage and alkali salts, but the soil generally is well drained. Owing to its sloping relief, irrigation is more difficult and less effective than in the typical soil. Crop yields and management practices are similar to those of Declo loam, slope phase.

Declo silt loam.—Most of Declo silt loam lies south of Aberdeen and is widely distributed among other soils of the Declo series. The total area is about 1½ square miles.

To a depth of about 12 inches this soil is light-brown to light grayish-brown mellow friable silt loam. This is underlain to a depth of about 4 feet by very light brownish-gray silty clay loam, which is the layer of accumulated lime. In the topmost few inches of this layer the material is compact and somewhat platy. The compaction decreases with depth, and the lower part is marked by soft spherical lime nodules and by veins of accumulated lime along the cracks. This layer rests on more friable and permeable rather indefinite but thick-bedded light grayish-brown strata. Stratified materials continue to the basalt bedrock. These vary considerably in texture and color but are mainly very fine sandy loam. A sprinkling of gravel is common over the bedrock in the shallower soils, and a few pieces of gravel occur throughout the soil material.

This soil has a level to slightly undulating surface that is favorable to irrigation. Erosion is at a minimum, yet surface run-off generally is complete. Internal drainage is sufficient, except in those areas where the soil is underlain by more clayey layers. Such areas are associated with areas of Declo loam and Declo silty clay loam, having the same underlying material, and an area of several hundred acres occurs west of Sterling. In these areas care must be exercised in prevention or removal of excess irrigation water.

This soil is closely associated with the loam and silty clay loam of the Declo series, and management practices and crops grown are very similar on all three. Yields are practically the same as those obtained on the silty clay loam.

Declo silt loam, slope phase.—The slope phase of Declo silt loam covers a small area, mostly in close association with other Declo soils south of Aberdeen. A few small areas are west of Sterling. Nearly all of the land is farmed. It has sloping to rolling relief, and care must be exercised in distribution of irrigation water not to accelerate erosion. The surface soil is thinner than in the typical soil and generally is definitely calcareous. The underlying uneven lava beds outcrop here and there, and in some areas the soil is comparatively shallow to bedrock.

The crops grown are the same as those grown on the slope phase of Declo silty clay loam, and similar yields are obtained. Management of this soil involves the same practices as for that soil.

Declo very fine sandy loam.—To a depth of about 12 to 14 inches the surface soil of Declo very fine sandy loam is light grayish brown, mellow, and friable. The soil materials are uniform throughout and slightly to mildly calcareous. Below this the slightly compact lime layer extends to a depth of about 36 inches. It contains some lime nodules, and lime veins are prominent. The color generally is very light brownish gray, and the texture is very fine sandy loam or fine-textured loam. In most places this layer is underlain by thick-bedded very fine sand of uniform floury character, but here and there more clayey strata are included. Quartzite gravel and fragments of basalt are sprinkled throughout the entire soil, which in most places is more than 6 feet thick. Gravel and basaltic frag-

ments are scattered over the basalt bedrock, and a few angular basalt stones and boulders are present.

Small areas of this soil are east of Aberdeen and northwest of Strang. The aggregate area is small.

The land is smooth and level to gently undulating. Surface and internal drainage are good. Although this soil is more permeable than the heavier Declo soils, it has excellent moisture-holding capacity. Water can be distributed uniformly and easily. Very little erosion occurs.

Only about half of the land is farmed, as gravity water is not available for the rest. The crops grown are the same as those grown on the other Declo soils. Alfalfa yields 4 to 5 tons of hay an acre, wheat 35 to 75 bushels, barley 55 to 85 bushels, oats 50 to 100 bushels, sugar beets 10 to 18 tons, and red clover seed 5 to 12 bushels.

Management of this soil is similar to that of Declo loam, but, because of the slightly higher lime content of the surface soil, it may require heavier and more frequent applications of phosphatic fertilizer for alfalfa, clover, and sugar beets.

Declo very fine sandy loam, slope phase.—Only a small area of the slope phase of Declo very fine sandy loam is mapped, chiefly in close association with the typical soil. Gravity water is available for only about one-half of the area, owing principally to its isolated position.

This soil is more sloping and has a thinner and more limy surface soil than typical Declo very fine sandy loam. Uniform distribution of water is more difficult than on that soil, and small heads of water are necessary for efficient irrigation and to prevent erosion.

Crops and yields are similar to those of the slope phase of Declo loam.

Declo fine sandy loam.—The total area of Declo fine sandy loam is small, and most of it lies in the vicinity of Aberdeen and northward. A few small bodies occur near Strang. All this land is under cultivation.

The surface soil to a depth of about 14 inches is light-brown or light medium-brown fine sandy loam. Inclusion of dark-colored basalt particles give a pepper-and-salt appearance. This layer is noncalcareous or slightly calcareous. The underlying layer of accumulated lime is about 3 feet thick. It consists of light brownish-gray or very light grayish-brown loam or silty clay loam, somewhat compact and containing nodules and veins of lime. Below this are thick-bedded gray pepper-and-salt loose fine sand and medium sand. This material continues to the lava bedrock, which lies about 6 feet below the surface. A few pieces of quartzite gravel are present throughout the soil and over the underlying basalt.

The areas in the immediate vicinity of Aberdeen are underlain by clayey strata, which make the soil somewhat less permeable than the typical soil. Drainage is apparently sufficient, however, as no waterlogging or concentrations of salts has developed. In these areas care should be exercised not to use too much water for irrigation.

The land is level to slightly undulating, and surface drainage is good. Except in the areas referred to above, no impediment to free movement of water is evident throughout the soil. The water-holding capacity is good, and absorption of water is rapid.

The same crops are grown as on the other Declo soils, but alfalfa and potatoes occupy a larger proportion of the acreage and produce slightly higher yields. Potatoes produce a high percentage of marketable grades of smooth tubers.

Alfalfa yields 3½ to 5½ tons of hay an acre or 5 to 14 bushels of seed, wheat yields 25 to 65 bushels, barley 30 to 70 bushels, oats 35 to 75 bushels, potatoes 250 to 450 bushels, sugar beets 10 to 15 tons, and red clover seed 5 to 12 bushels.

Similar crop rotations, including alfalfa or other legumes, are used as on the other soils of the area, to supply nitrogen and organic matter. Phosphate fertilization at present is not so essential as on the more calcareous Declo soils. Owing to removal of surface soil in leveling, however, highly calcareous spots should be treated in order to give more uniform stands of alfalfa, sugar beets, and clover seed. With continued irrigation the lime concentration increases and the application of phosphate becomes more necessary for satisfactory yields.

The border method for hay and grain and the furrow method for the intertilled crops are the usual practice in irrigating this soil. Because of the smooth surface, control of erosion is not a problem.

Declo sandy loam.—The 15-inch surface soil of Declo sandy loam is medium-brown or light-brown sandy loam containing dark-colored grains of basalt, which give a pepper-and-salt appearance. The lime layer, which extends to a depth of about 48 inches, is very light grayish-brown or light brownish-gray heavy loam or clay loam. This layer is somewhat compact and contains calcareous spherical nodules and lime veins. Underneath this are thick strata of grayish-brown or gray sand darkened by a sprinkling of basalt grains. These strata continue to the underlying lava beds, which lie at a variable depth below 6 feet. A sprinkling of quartzite gravel and basalt fragments occurs over the basalt, and a few are in the soil proper. The surface soil generally is not calcareous or only slightly calcareous, except where leveling has exposed the lime layer.

The total area of this soil is small. Small bodies are widely distributed over the Aberdeen terrace, but the greater part lies north of Aberdeen. Most of the land is farmed.

The surface is smooth and nearly level to gently undulating. Surface drainage is good, and internal drainage is sufficient. Irrigation water is easily distributed and rapidly absorbed. Because of the heavier textured lime layer, the water-holding capacity is fairly good, but more frequent irrigation and shorter runs of water are generally needed than on the heavier soils. Erosion is at a minimum because of the smooth surface.

All the common crops of the area are grown on this soil, but it is especially favorable for the production of alfalfa and potatoes. Alfalfa yields 3½ to 5½ tons of hay an acre or 5 to 14 bushels of seed, potatoes 250 to 450 bushels, wheat 25 to 65 bushels, barley 30 to 70 bushels, oats 35 to 75 bushels, sugar beets 10 to 15 tons, and red clover seed 5 to 12 bushels.

In addition to crop rotation including alfalfa or other legumes, it appears that most satisfactory yields are maintained where barnyard manure and crop residues are added to the soil. This is because of the deficiency in both nitrogen and organic matter, owing especially to the light texture of the soil. The organic-matter con-

tent should be held at a high level also to prevent wind erosion. The surface soil is generally noncalcareous or only slightly calcareous. The calcareous areas, especially scraped spots, can be improved by the application of phosphate.

Declo sandy loam, slope phase.—The slope phase of Declo sandy loam is inextensive. It occurs in small areas, mostly north of Aberdeen and south along the reservoir. About three-fourths of this soil is farmed.

The land is sloping to rolling. The surface soil is not so thin or so variable as in the slope phases of other Declo soils, because the mantle of surface soil has been distributed by the wind. The undulating relief is caused in part by such deposition. Included small areas have a fine sandy loam surface soil that is generally noncalcareous or only slightly calcareous, but spots of high lime content occur where the subsoil has been exposed by leveling for irrigation.

The crops grown and rotations followed are the same as on the typical soil. Yields are slightly lower, as the surface soil is more variable and the relief makes efficient irrigation more difficult. Alfalfa yields 3 to 4½ tons of hay an acre or 5 to 14 bushels of seed. Potatoes yield 175 to 325 bushels, wheat 20 to 45 bushels, barley 25 to 60 bushels, oats 25 to 60 bushels, sugar beets 8 to 12 tons, and red clover seed 3 to 8 bushels.

This soil is benefited by the addition of barnyard manure and other organic residues besides that supplied by rotation with alfalfa or other legumes. Such additions will help to maintain the fertility and also to decrease erosion by wind and water. Applications of phosphate would be beneficial, especially on the highly calcareous spots.

The furrow method of irrigation is used for the most part. Small heads of water and short runs give better saturation and reduce erosion.

Declo loamy fine sand.—To a depth of about 16 inches Declo loamy fine sand is medium-brown or light grayish-brown slightly loamy fine sand containing scattered dark grains of basalt. It is noncalcareous or slightly calcareous and is soft or loose. The underlying lime layer, which continues to a depth of about 48 inches, is much more compact than the surface soil and contains spherical nodules and lime veins. It consists of very light grayish-brown or light brownish-gray sandy loam or loam. The underlying materials are sand and loamy sand occurring in loose thick-bedded strata. They have a gray pepper-and-salt appearance. Quartzite gravel occurs here and there throughout the soil and immediately over the surface of the lava beds, which lie at a variable depth, generally below 6 feet.

Scattered bodies, with a small total acreage, are north of Aberdeen. Most of the land is farmed.

The surface is smooth and nearly level to gently undulating. Surface drainage is good, and internal movement of moisture is rapid. The lime layer aids in retaining moisture, and the soil holds moisture sufficiently well to mature crops, although more frequent application and shorter runs are necessary in irrigation than on other Declo soils. Both the border and furrow methods of irrigation are satisfactory.

All the crops common to the area are grown to some extent, but the largest acreage is devoted to alfalfa and potatoes. Alfalfa yields 3 to

4½ tons of hay an acre or 5 to 14 bushels of seed, potatoes 220 to 350 bushels, wheat 20 to 55 bushels, barley 25 to 60 bushels, and oats 25 to 60 bushels.

All available manure and organic residues are needed, in addition to amendments supplied by crop rotation with legumes, in order to maintain the content of organic matter and nitrogen, which, under natural conditions, are very low. Such treatment checks both water and wind erosion. The content of available phosphate is not critically low, except on highly limy spots resulting largely from leveling.

Declo loamy fine sand, slope phase.—Small bodies of the slope phase of Declo loamy fine sand are widely distributed in close association with areas of the typical soil north of Aberdeen. It differs from the typical soil mainly in its sloping to rolling relief. Compared with the corresponding features of that soil, the surface soil is more variable in depth, and almost white spots of the limy subsoil have been exposed in many places by water and wind erosion and by scraping in leveling for irrigation. The entire soil is more variable in depth than the typical soil, and the underlying lava beds outcrop here and there. Distribution of water is more difficult than on the typical soil, and small heads of water and shorter runs are necessary for effective irrigation. The furrow method of irrigation is used almost exclusively. Small heads of water minimize erosion.

The crops grown are the same as on the typical soil. Crop yields are probably one-fourth smaller than on that soil. The same management as on the typical soil must be followed strictly in order to obtain satisfactory yields.

Fingal sandy loam.—The 14-inch surface soil of Fingal sandy loam is light grayish-brown or medium grayish-brown friable sandy loam of granular structure. A high proportion of water-worn rounded particles of basalt sand imparts a considerably darker color. Rounded quartzite pebbles are sprinkled over the surface and throughout the soil material. In places the surface soil is slightly to strongly calcareous. This layer is underlain to a depth of about 40 inches by a calcareous layer of light yellowish-gray or brownish-gray gritty silty clay or silty clay loam. The material in this layer has a mealy consistence and breaks horizontally in the lower part. Underneath are thick strata of light greenish-gray or light yellowish-gray blocky clay. Rusty-brown iron staining and mottling occur throughout. Roots become matted in the cracks. These clay layers are in places interstratified with silty and sandy beds at a depth below 15 to 20 feet. The depth of the soil material over the basalt bedrock is extremely variable.

A few small areas 2 miles northeast of Sterling have a surface soil of loamy sand. Most of these are high in salts and are used only for pasture. In the immediate vicinity of Lower Presto School the texture of the surface soil is heavier, approaching loam, and in places it is very fine sandy loam.

This soil is widely scattered in comparatively small bodies along the shore line of the American Falls Reservoir north and south of Sterling and in the vicinity of Lower Presto School. Much of this soil is of the best drained part of the Sterling terrace; yet less than one-third is farmed, owing to seepage and accumulations of salts.

The surface is flat or slightly sloping. Drainage on the immediate surface generally is sufficient, but internal drainage is slow because of the impermeable clay beneath. This clay acts as a dike, impeding drainage waters from all the area lying back from the reservoir. Seepage from excess irrigation water and accumulations of salts are encroaching on the farmed areas. Open drains are used in a few places, but they are not deep enough or numerous enough to drain this impervious clay.

Most of the farmed land is devoted to alfalfa for hay and seed. Potatoes and sugar beets are sometimes grown. Sugar beets have a relatively high tolerance for salts. Alfalfa yields from 2 to 5 tons of hay an acre or 3 to 8 bushels of seed, potatoes 125 to 225 bushels, and sugar beets 7 to 12 tons.

The uncultivated land, most of which is high in salts, is used for pasture. It supports saltgrass to the exclusion of almost all other vegetation except greasewood. This grass furnishes coarse forage and has a low carrying capacity. Livestock enterprises, however, are the largest source of cash income on this soil.

Like all the Fingal soils, this soil is low in organic matter and nitrogen, and it is necessary to carry out a rotation, including alfalfa or other legumes to supply these deficiencies. Supplementary applications of organic manure and phosphate give marked benefits.

Fingal loam.—The surface soil of Fingal loam to a depth of about 12 inches is light-brown or dull grayish-brown gritty granular loam. It contains much dark-colored basalt sand and scattered quartzite gravel. It is only slightly calcareous, except in association with soils containing accumulations of salts. The concentrated lime layer consists of light brownish-gray moderately compact gritty heavy loam or silty clay. Like the layer above, it generally contains a scattering of gravel. At a depth of 40 inches the lime layer rests on strata of greenish-gray blocky clay containing reddish-brown iron staining as a result of poor drainage. These strata continue to a depth of 20 to 40 feet, where they overlie basalt bedrock.

The soil is widely distributed along the reservoir north and south of Sterling. Less than one-half of the land is farmed, owing to encroachment of accumulations of salts. Many areas previously farmed now are used only for pasture. On such areas saltgrass and greasewood are the principal plants.

On this flat land water moves slowly off the surface and cannot readily penetrate the heavy clay subsoil. The areas not farmed are waterlogged, and very little artificial drainage has been attempted. Natural drainage is not sufficient to carry off the excess water in the back-terrace positions, and accumulating water becomes an increasing menace to areas that are still producing crops. The water table stands at or very near the surface in the salt-affected areas, where a few open drains carry off some of the surface water but do not materially improve the underdrainage.

The same crops are grown as on the other Fingal soils. Alfalfa occupies about two-thirds of the area, but yields are low, as the surface soil is heavy and shallow over the tough comparatively impermeable clay. Grains, sugar beets, and some potatoes are grown in rotation with alfalfa. Alfalfa yields from 1½ to 3 tons of hay an acre, wheat

20 to 55 bushels, barley 30 to 60 bushels, oats 30 to 65 bushels, and sugar beets 8 to 12 tons. Potatoes do not grow very satisfactorily, because of the heavy surface soil over the tough highly impenetrable subsoil. Yields range from 125 to 250 bushels an acre. The salt-affected areas are used extensively for pasture, and the sale of livestock products supplies a large part of the cash income.

For proper tilth the heavy surface soil requires organic manures, in addition to those supplied in crop rotation with alfalfa and other legumes. It is also necessary to plow and cultivate this soil under proper moisture conditions.

Fingal loam, slope phase.—Only a very small area of this soil is mapped. It is closely associated with the typical soil, from which it differs in having a thinner surface soil and sloping to rolling relief. Irrigation is more difficult and yields are lower than on that soil. Crop production is reduced by accumulations of salts, and much of the land is used for pasture. A few small areas of silty clay loam are included. The surface soil in these areas is very thin and rests directly on the clay, and in a few places the clay subsoil is exposed. In such areas erosion takes place rapidly.

Fingal fine sandy loam.—To a depth of about 14 inches the surface soil of Fingal fine sandy loam is medium-brown or grayish-brown calcareous mellow fine sandy loam. It is underlain to a depth of about 36 inches by mottled light brownish-gray highly calcareous silty clay loam. Below this is light greenish-gray fine-blocky clay containing a high accumulation of lime and discolorations resulting from stagnated drainage. At a depth of about 36 inches this rests on highly stained and mottled dense blocky clay.

Small bodies of Fingal fine sandy loam are closely associated with bodies of the Logan, Blackfoot, and other Fingal soils. This soil occupies slightly higher positions than the former two soils but has a comparatively flat surface with occasional low swells and slight depressions. Only a few small areas are farmed. The water table is within a few feet of the surface, and accumulations of salts occur. In most places only salt-tolerant vegetation of alkali weeds, saltgrass, and greasewood can grow to any extent, and these plants afford only poor pasturage. Reclamation of this soil would be difficult and expensive.

Fingal fine sandy loam, slope phase.—This soil covers a small total area. Most of it lies west of Sterling, but small bodies are widely distributed over the Sterling terrace. A few small areas that have a sandy loam, very fine sandy loam, and loamy fine sand surface soil are included in mapping.

This soil differs from typical Fingal fine sandy loam in having a sloping to rolling relief and a less uniform surface soil. This is due to both water and wind erosion. The mantle of fine soil material over bedrock or gravel beds generally exceeds 6 feet in thickness, but in a few places loose basalt rocks on the surface indicate a very shallow soil. In most places quartzite gravel is scattered throughout the surface soil.

Only a very small part of this soil is farmed, owing to concentrations of salts, which limit its use to grazing in most places. Where farmed, the same crops are grown and similar yields obtained as on

the slope phase of Fingal loam. The carrying capacity of the salt-grass pasture is not high, but considerable revenue is obtained through the sale of livestock products supported by such pasture.

Fingal loamy sand.—The surface soil of Fingal loamy sand to a depth of about 14 inches is light-brown or dull medium-brown loamy sand containing light-colored quartz and dark-colored basalt sand grains, which give the material a pepper-and-salt appearance. This material is moderately calcareous and contains small shells and fragments of shells throughout. Below this is a lime layer of light grayish-brown firm but not compact fine sandy loam. The color is uniform throughout, and a few small spiral shells and fragments of shells are present. This material is underlain at a depth of about 36 inches by very light grayish-brown silty clay loam that is veined with lime and is somewhat compact. Soft spherical nodules are present in some places. Below a depth of 72 inches is drab or grayish-brown gritty loam, with discoloration caused by poor drainage. It is sprinkled with small shells. At a depth of 10 to 15 feet the material is interstratified with gravelly and clay strata.

Fingal loamy sand occurs only in the sand-dune area east of Blackfoot. This area of dune-and-basin relief parallels the Blackfoot River from Blackfoot to the vicinity of Lower Presto School. The soil occupies the flat basins, which are widely distributed among the hummocks and dunes, and in many places it is the only tillable land available. Farmers often endeavor to add to their arable acreage by leveling the smoother surrounding sandy areas. In such basins the texture of the surface soil generally is sand. Although poorly drained basins are scattered throughout this area, this soil generally occupies the better drained basins. In some of them, however, the lower subsoil layer and substratum are waterlogged, but as yet the water table is sufficiently low to allow the production of most crops. The water table usually rises with the irrigation season.

Most of this soil is farmed. Adapted crops are few because of the light texture; they are confined mainly to alfalfa, small grains, and potatoes. The land is less suited to the production of small grains than to the other crops, but these fit into the rotation. Probably about three-fourths of the land is devoted to the production of alfalfa for hay and seed. Alfalfa yields from 2 to 5 tons of hay an acre or 3 to 10 bushels of seed, potatoes 125 to 300 bushels, wheat 15 to 30 bushels, barley 10 to 40 bushels, and oats 15 to 40 bushels. The surrounding sand dunes support a sparse growth of bunchgrasses, which are pastured, so that cash income in this district is from livestock products as well as from cash crops.

This sandy soil is subject to severe wind erosion; therefore great care must be exercised in cultivation. A further danger is caused by sand blowing in from the surrounding sand dunes; therefore care should be taken to keep the soil materials stabilized as much as possible. Crop rotation is not so strictly adhered to as on most of the other soils of the area, and frequently alfalfa is left growing for many years because it prevents blowing. It is generally conceded that continued irrigation also helps to stabilize the soil materials. Soil that once was very hard to control can now be cultivated more freely. Residues

from alfalfa and other crops and barnyard manure contribute to stabilization.

The border method of irrigation is the most satisfactory for alfalfa and grains and the furrow method for potatoes. Short runs with fairly large heads of water are necessary because of the porous character of the soil. Frequent irrigation is necessary, but the water should be run for only a short time.

Fingal sand.—To an average depth of about 16 or 18 inches Fingal sand is light medium-brown loose sand with a pepper-and-salt appearance due to light-colored quartz and dark-colored basalt grains. It is slightly calcareous and contains a few small shells and fragments of shells. Below this a layer of light-brown or gray silty clay loam, veined with lime and slightly compacted, extends to a depth of 38 inches. The abrupt change from the sand above suggests that the surface sand has been laid over the finer textured material by the wind. The variable depth of the surface soil from place to place further supports this theory. Between depths of 38 and 60 inches is a silty clay, which when moist has a drab or grayish-brown color with a slight green tinge and when dry is light gray. This peculiar color is due to poor drainage. This material contains numerous shells, fragments of shells, and veins of lime. This layer overlies a more friable layer of light grayish-brown loam sprinkled with very fine gravel and containing a concentration of lime and many shells, and this in turn overlies more porous gravelly strata cross-bedded with clay.

Fingal sand occurs in small basins in the same sand-dune district as Fingal loamy sand, but it is less extensive. Although only a small part is farmed at present, the cultivated acreage may be extended, as the soil lies in this district where arable land is so limited. Control of the shifting sand is more difficult than in Fingal loamy sand. Alfalfa for hay and seed is the chief crop, but yields are smaller than on the loamy sand. Frequent irrigation will be essential, but each application should be light. Cash income is derived mainly from the sale of livestock products, as the surrounding dune sand affords some pasturage.

Fingal sand, hummocky phase.—The hummocky phase of Fingal sand covers an area of about 15 square miles in the dune-sand district, extending from east of Blackfoot to Lower Presto School. Sand dunes, ridges, and hummocks are characteristic, and the shifting sand is a pepper-and-salt mixture of quartz and basaltic particles. The sparse vegetation of coarse bunchgrasses, brush, and flowering annuals is not sufficient to hold the sand, and considerable movement takes place every year. The sand surface soil in many places is calcareous owing to the distribution of limy materials by winds. Gravel occurs as in the other deposits of the sand-dune district, but it is less common.

Numerous basins and flat areas occupied by the typical Fingal soils are within the larger areas of this soil. Fingal sand, hummocky phase, lies above these basins and is not affected by seepage or accumulations of salts. It does not have the same heavy subsoil as other Fingal soils, but indications are that it is underlain at a greater depth by similar clay strata.

This soil affords some pasturage for livestock.

Fingal silty clay loam.—The surface soil of Fingal silty clay loam to a depth of about 10 inches is grayish-brown moderately to highly

calcareous silty clay loam that is slick and plastic when wet and hard and grayer when dry. The surface soil is matted with roots. It is underlain to a depth of 36 inches by a more highly calcareous layer of light-gray or brownish-gray silty clay with rust-brown, blue, and green stains caused by poor drainage. The structure is granular or blocky. Below this is mottled very light greenish- or bluish-gray, almost white, very plastic clay. Below a depth of 60 inches these materials are much mottled with rusty red and bluish green. They overlie dense blocky clay.

A small part of this soil, in which the underlying clay is less massive than is typical, occurs on the upper terrace southeast of Springfield. In a few small included areas the texture is slightly lighter than typical.

This soil occurs mainly on the Sterling terrace, where it occupies small areas slightly above areas of the Logan and Blackfoot soils and adjoins areas of other Fingal soils. The aggregate area is not large.

The land is comparatively flat, in places depressed, to slightly undulating. Surface run-off is slow, and internal drainage is restricted. The water table is usually only 1 to 2 feet below the surface and fluctuates with the irrigation season, but the soil is always saturated with moisture. Concentration of salts is too high for crop plants, and none of the land is used for farming. The principal vegetation is saltgrass, alkali weeds, and greasewood. This cover has a low carrying capacity for livestock.

A few shallow local drainage ditches have been installed on the Sterling terrace to expedite surface run-off, but drainage is very inadequate for this and associated soils. Drainage is here a community problem and probably would be too expensive to be justified under present economic conditions.

Bannock silty clay loam.—In the virgin condition the topmost 3 inches of Bannock silty clay loam is light-brown or medium-brown friable and mellow silt loam or silty clay loam. This material forms soft blocks or slabs distinctly separated from the layer below. It is underlain to a depth of 16 to 18 inches by medium-brown or light-brown heavy silt loam or silty clay loam that is slightly firmer and harder. The above layers contain little or no lime, but in irrigated areas they are slightly calcareous. In low positions below terrace breaks this layer extends to a depth of 20 to 26 inches. In such areas more organic matter has accumulated and the soils are definitely browner than elsewhere. Below this layer is lighter grayish brown silty clay loam that is compact and rather hard when dry. It is veined with lime. Lime-cemented nodules are faintly developed, and vertical cracks are present. The layer of highest lime concentration lies under this material between depths of about 30 and 48 inches. This material is very light brownish-gray or nearly white compact silty clay loam containing some gravel and spherical lime-cemented nodules that break apart with the material. It is hard when dry but softens when wet. It rests abruptly on loose thick-bedded gravel and sand. The gravel consists mainly of light-colored quartzite, but about half of the sand consists of basalt grains. Some slight coating of lime appears on the gravel in many places.

This soil has the thickest noncalcareous surface layer and generally contains the most organic matter of the soils of the Bannock series.

There is, however, considerable variation in these respects, and in a few places the limy subsoil is exposed in leveling for irrigation. In most places gravel is sprinkled throughout the upper layers, but in some areas of the thicker soil there is no gravel.

The total area of this soil is large. Long narrow bodies extend the entire length of the gravelly valley floor. Practically all of the land is under cultivation.

The smooth almost flat to very gently sloping surface favors the efficient distribution and application of water. The water-holding capacity is the best in the Bannock soils, although not quite so good as in the soils of the uplands and lake terraces. Because of the open porous gravelly substratum, moisture is held effectively only in the upper layers. The plentiful supply of water available makes it possible to compensate for this limitation in water-holding capacity by allowing more frequent irrigation. Internal drainage is sufficient to remove excess water, and all this soil is free from seepage and alkali salts.

This is the most productive Bannock soil. Although its texture is slightly heavier than is most desirable for some crops, the higher humus content and the low lime content of the surface soil keep it at a high productive level when proper rotation, including alfalfa or other legumes, is followed. Phosphate fertilization is not so essential as on the other Bannock soils except on spots of high lime content resulting from leveling. Most farmers apply barnyard manure, which materially aids in increasing and maintaining the fertility.

All crops common to the area are grown on this soil. Alfalfa occupies about half of the land, small grains less than one-fourth, and cash crops the rest. Alfalfa yields 3 to 4½ tons an acre, wheat 35 to 80 bushels, potatoes 225 to 350 bushels, sugar beets 8 to 15 tons, peas 15 to 45 bushels, beans 15 to 35 bushels, and red clover seed 5 to 12 bushels.

The border method of irrigation is very satisfactory for alfalfa, red clover, and small grains, and the furrow method is best for intertilled crops. Flooding should be eliminated in the irrigation of peas and beans, as it will cause scalding and reduces the salable seed.

Bannock gravelly silty clay loam.—Bannock gravelly silty clay loam, an inextensive soil, occupies small widely distributed bodies, mostly northeast of Blackfoot. All the land is farmed.

This soil differs from Bannock silty clay loam in having a rather high content of gravel throughout, thinner comparable layers, and generally a definitely to highly calcareous surface soil. The ease of cultivation is materially reduced and the water-holding capacity and fertility are lower, compared with those features of the silty clay loam, because of the content of gravel. The relief is less favorable for irrigation than the relief of that soil, being undulating to gently sloping. A few scraped spots of a shallow, very gravelly, highly limy soil are included. All these factors tend to reduce yields from one-fourth to one-third less than those obtained on Bannock silty clay loam.

Although management of this soil is very similar to that of Bannock silty clay loam because of the close association, yields would be materially increased by more frequent application of barnyard manure supplemented with phosphate. Irrigation practices are about the same

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as on that soil, but the water requirement is higher, and more frequent irrigation is needed.

Bannock loam.—The 16-inch surface soil of Bannock loam is light-brown or light grayish-brown friable mellow loam containing scattered quartzite gravel. In the virgin soil a thin soft blocky layer is present at the surface, the surface soil is leached of lime, and the lower part is browner and slightly more compact. Under cultivation this material becomes slightly to mildly calcareous. It is underlain by light yellowish-gray or light brownish-gray silty clay loam, veined with lime and containing soft spherical nodules. Considerable compaction and a higher lime content occur at the bottom of this layer. This material changes abruptly at a depth of about 48 inches to a loose porous bed of gravel and coarse sand. Most of the gravel is quartzite, and more than half of the sand is coarse basaltic sand. These materials continue to an undetermined depth. With depth the content of gravel increases, and rounded small stones of similar origin are mixed with it.

Scattered gravel occurs in most places throughout the soil, but the quantity varies considerably from place to place. In a few places the soil material is almost free of gravel and the soil layers generally are thicker and the surface soil more deeply leached than elsewhere.

The total area of this soil is fairly large, and the bodies are widely distributed. All the land that lies outside the Fort Hall Indian Reservation is farmed. On the reservation about one-half is as yet undeveloped.

The land is smooth and level to slightly undulating. Surface drainage is good, and internal drainage is excessive below the lime layer. The moisture-holding capacity is fairly good but not so good as that of Bannock silty clay loam. Sufficient water is available to mature crops, although more frequent irrigation is needed than on deeper soils. Irrigation water can be distributed effectively, and the water is absorbed readily. The border method is used for hay and small grains and the furrow method for cultivated row crops.

This soil has a texture that makes it easy to work. It is well suited to and extensively used for all the common crops of the area. The rotations, crop distribution, and management of this soil are about the same as those of Bannock silty clay loam. In general, there is more need for organic manures and phosphate than on that soil.

Alfalfa yields 3 to 5 tons an acre, wheat 30 to 75 bushels, barley 50 to 90 bushels, oats 55 to 100 bushels, potatoes 250 to 400 bushels, sugar beets 8 to 16 tons, peas 15 to 40 bushels, beans 15 to 40 bushels, and clover seed 4 to 10 bushels.

Bannock gravelly loam.—Bannock gravelly loam is widely distributed in close association with Bannock loam. It differs from that soil in the high content of gravel throughout and in the thinner surface soil and thinner lime layer above the porous gravelly subsoil and substratum. It is less productive, as it has lower water-holding capacity and lower fertility than that soil. It is more difficult to plow and cultivate and causes greater wear on the implements. As it is more calcareous, it is in greater need of phosphate fertilization. There is also critical need of organic manures to supply organic matter and nitrogen, in which this soil is deficient.

As mapped, a few small areas of gravelly silt loam and gravelly fine sandy loam are included.

The same crop rotations, including alfalfa and other legumes, and about the same management practices are followed as on Bannock loam. As the water-holding capacity of this soil is lower, more frequent irrigation is needed and would increase yields. About the same crops are grown as on Bannock loam, but yields are one-fourth to one-third less.

Bannock gravelly loam, slope phase.—Small bodies, aggregating a small total area, of the slope phase of Bannock gravelly loam are widely scattered throughout areas of both the loam and gravelly loam of this series. This soil differs from typical Bannock gravelly loam in the sloping to rolling relief, which makes irrigation more difficult and less effective. Where it is closely associated with Bannock loam, the soil has somewhat deeper surface soil, contains less gravel, and does not produce such low yields as elsewhere. In general, however, yields are much lower than on typical Bannock gravelly loam, varying considerably with the gravel content and the degree of slope. Small heads of water and short runs are necessary for effective irrigation. The gravel content of the soil reduces erosion so that it is less marked than on deeper, less gravelly soils.

Bannock gravelly loam, shallow phase.—Bannock gravelly loam, shallow phase, is mapped chiefly in the vicinities of Moreland and Wapello. This soil differs from typical Bannock gravelly loam in having a shallow very gravelly surface soil that overlies a more gravelly compact lime layer. When the land is plowed the lime layer mixes with the surface soil, giving the soil a gray appearance. The entire soil is thin, and the water-holding capacity is low. Plowing and cultivating are made difficult by the high gravel content. In the vicinity of Moreland the gravel content is equally high, but the surface soil is deep enough to cover the gray subsoil so that it is not exposed at the surface. Crop yields are therefore higher in that vicinity than elsewhere. On the average this soil produces lower yields than the slope phase of Bannock gravelly loam.

Bannock silt loam.—To a depth of about 12 to 14 inches the surface soil of Bannock silt loam is light-brown to light grayish-brown mellow silt loam. In the virgin condition a soft blocky layer a few inches thick covers the slightly heavier textured and browner subsurface soil. Plowing mixes these materials, and irrigation makes them more or less calcareous. The layer below this consists of light grayish-brown moderately calcareous heavy silt loam or silty clay loam with vertical cracks. This material is firm but not compact. It is underlain at a depth of about 24 inches by more compact silty clay loam containing lime in the form of vein, streaks, and spherical nodules. This is the layer of accumulated lime. A sprinkling of gravel occurs throughout this layer and the surface soil. The lime layer caps loose porous beds of sand and gravel. The gravel, mostly quartzite, has some lime coating in many places. The sand is coarse and consists in part of rounded basalt grains. Stratification is indefinite. The gravel content increases with depth, and at a greater depth rounded stones occur. This material continues to an undetermined depth.

A few areas are almost free from gravel above the gravelly subsoil and substratum. Here the soil layers generally are thicker than in the typical soil.

This soil occurs mainly west of the Snake River and north of Blackfoot. Practically all of the land is under cultivation.

The land is smooth and nearly level to very gently undulating. Surface drainage and internal drainage are good, and subdrainage is excessive, but the water-holding capacity of the layers above the gravel strata is excellent. Irrigation water can be very effectively distributed. Because of the effective drainage, seepage and concentration of salts do not develop. Water is plentiful for irrigation.

All the crops common to the area are grown, and good yields are obtained where a crop rotation including alfalfa or other legumes is followed. Barnyard manure is very beneficial, producing marked increases in yields of alfalfa, sugar beets, and clover seed. Phosphate fertilizer also is beneficial, especially when applied to calcareous spots, many of which result from leveling for irrigation. Crops are similar to those grown on Bannock silty clay loam. Alfalfa yields 3 to 4½ tons an acre, wheat 30 to 75 bushels, barley 55 to 85 bushels, oats 55 to 105 bushels, potatoes 225 to 400 bushels, sugar beets 7 to 14 tons, peas 15 to 35 bushels, beans 15 to 35 bushels, and clover seed 4 to 12 bushels.

Bannock very fine sandy loam.—Bannock very fine sandy loam, an inextensive soil, occurs in small bodies widely distributed throughout the valley floor but generally in close association with bodies of Bannock silt loam. Except for the surface soil, it is almost identical with that soil and has similar variations. Both soils have developed from materials that contain much fine floury wind-borne loess. This soil has the same favorable relief for irrigation as the silt loam, and it holds water very well. Crops grown, management practices followed, and yields obtained are about the same on the two soils, although occasionally on this soil the yields of alfalfa and potatoes are slightly higher and yields of small grains lower than on the silt loam.

Bannock very fine sandy loam, slope phase.—This soil, occurring mainly west of the Snake River, covers about the same total area and has about the same distribution as the typical soil. Southwest of Ferry Butte, in the shallow basins of the lava beds, most of the soil is very gravelly. Little farming, however, is carried on in this district. Altogether, only about one-half of the land is farmed throughout the area. In the farmed areas the soil is more uniform and almost free of gravel on the surface, although the surface soil is more variable in depth and generally shallower than in the typical soil. The land is sloping to somewhat rolling, and leveling for irrigation has uncovered spots of the limy subsoil and distributed calcareous material over the surface soil in other places. Irrigation is more difficult and expensive and is less effective. The more uneven distribution of water and the thinner surface soil, which is highly calcareous in places, depress yields so that they are one-fourth to one-third less than those obtained on typical Bannock very fine sandy loam. The same crops are grown as on that soil, and efforts are made to keep yields as high and as uniform by the application of barnyard manure and phosphate. Irrigation is mostly by the furrow method, small heads of water being used to give better results and minimize erosion.

Bannock fine sandy loam.—To a depth of about 12 to 14 inches the surface soil of Bannock fine sandy loam consists of light-brown to light grayish-brown fine sandy loam. This friable and mellow material is easily cultivated. In the virgin condition this layer is not limy and the upper few inches of material form a soft blocky or slablike layer. Under cultivation these materials are mixed, and under irrigation they become calcareous. This layer is underlain to a depth of about 20 inches by a more compact layer of light-brown mildly calcareous loam. The compact lime layer below this is very light brownish-gray or almost white silty clay loam containing veins of lime and some soft spherical nodules. At a depth of about 40 inches this layer rests on the porous gravelly sand substratum, which continues to an undetermined depth. Most of the gravel is light-colored quartzite, and the sand is a mixture containing a high proportion of dark basalt grains.

Generally there is a sprinkling of gravel throughout the soil, but in a few areas gravel is almost absent. In many such areas the noncalcareous surface soil and the underlying layers are thicker.

This soil is widely distributed over the Gibson terrace. It covers about 15 square miles, more than one-half of which lies in the Fort Hall Indian Reservation. Practically all of the land lying outside the reservation is farmed, but within the reservation less than one-half of the land is under cultivation at present.

The land is smooth and nearly level to slightly undulating. The nearly level surface lends itself to an even distribution and effective application of water. Moisture is retained well, although not so effectively as in soils of heavier texture. The water supply is plentiful, however, and crops mature satisfactorily. Underdrainage is complete, and seepage and concentration of salts have not developed.

All the common crops of the area are grown on this soil, although on the reservation alfalfa for hay and seed is preferred by the Indians. Alfalfa and potatoes give particularly large returns, and yields of other crops are also high. Alfalfa yields 3½ to 5½ tons of hay an acre or 5 to 15 bushels of seed, wheat 20 to 60 bushels, barley 30 to 65 bushels, oats 30 to 70 bushels, potatoes 225 to 400 bushels, sugar beets 10 to 15 tons, clover seed 5 to 10 bushels, peas 10 to 35 bushels, and beans 15 to 40 bushels.

The border method of irrigation is used for alfalfa and small grains and the furrow method for intertilled crops, including peas and beans.

Outside of the reservation alfalfa occupies about one-half the acreage, wheat and other small grains more than one-fourth, and the rest is used in rotation for cash crops, especially potatoes. Management problems are not essentially different from those of the other Bannock soils. Crop rotation including alfalfa and other legumes is essential for the maintenance of an adequate supply of organic matter and nitrogen. This soil benefits especially from all organic manures because of its lighter texture. Because of the more effective leaching in this soil, the lime content is low, and it appears to remain so even after irrigation. This makes phosphate more available, and phosphate fertilization is not so necessary as on the more calcareous soils. Scraped limy areas resulting from leveling are more productive if given superphosphate fertilizer and should be so treated to make uniform yields.

Bannock gravelly fine sandy loam.—Bannock gravelly fine sandy loam is widely distributed from the vicinity of Moreland to a point southeast of Springfield, and a large part is within the Fort Hall Indian Reservation. Most of the land outside the reservation is farmed, but within the reservation only about one-half is in farms.

This gravelly soil differs from Bannock fine sandy loam in having a high content of gravel, which is prominent in the surface soil and predominant in the subsoil. The entire soil above the droughty lower subsoil layer and substratum is shallow, in a few places exceeding 30 inches in thickness. The surface soil is moderately to strongly calcareous. The high gravel content of the surface soil makes plowing and cultivating more difficult, and farm machinery depreciates more rapidly than on the nongravelly soil. The gravel throughout the soil and the shallowness of fine soil material decreases both the water-holding capacity and the fertility. Although the surface is smooth and favorable to uniform distribution of water, frequent irrigation and short runs are necessary. The use of barnyard manure and other organic residues, in addition to the crop rotation including alfalfa or other legumes, increases both the moisture-holding capacity and the fertility. On the reservation alfalfa for hay and seed is the principal crop; elsewhere all crops are grown. Yields are probably one-fourth less than on Bannock fine sandy loam.

Bannock gravelly fine sandy loam, shallow phase.—The shallow phase of Bannock gravelly fine sandy loam occurs mainly in the vicinity of Moreland. Although the proportion of gravel is large in the surface soil and very large in the subsoil, the soil is not so shallow as the other shallow phases of the gravelly Bannock types. The surface soil generally is more deeply leached because of its porous character, and in many places it is not calcareous even when irrigated, although the layer of accumulated lime is exposed in small spots. The lime layer continues to greater depth than in the other gravelly phases; it is not so compact, and it is not so abruptly underlain by the porous substratum of gravel. The lay of the land generally is smooth enough to allow effective distribution of irrigation water, but the soil does not hold water very well. Frequent irrigations, therefore, with short runs are necessary for the satisfactory production of crops. Rigid adherence to crop rotation including alfalfa or other legumes, and supplementary applications of manure and organic residues, are needed to improve the moisture-holding capacity and fertility.

All the crops of the area are grown, but alfalfa and potatoes are the most satisfactory. Alfalfa yields 1½ to 3 tons an acre and potatoes 125 to 250 bushels. Yields of other crops are materially lower than on Bannock gravelly fine sandy loam.

Bannock gravelly fine sandy loam, slope phase.—The slope phase of Bannock gravelly fine sandy loam occupies a small total area, chiefly in the vicinity of Moreland. In that vicinity the relief is undulating to somewhat rolling and the soil is similar to the typical soil. Elsewhere the soil occupies slopes around drainage depressions and along terrace breaks. Here the surface soil is less gravelly but thinner than it is near Moreland, has a variable depth, and generally is definitely to strongly calcareous. The uneven relief in this soil makes irrigation less effective, and more time is required for the ap-

plication of water because of shorter runs and smaller heads. The water requirement is high for satisfactory production of crops.

About the same crops are grown and about the same rotations and management practices are followed as on the typical soil, but yields are less.

Bannock loamy fine sand.—The surface soil of Bannock loamy fine sand to a depth of 14 or 16 inches is medium-brown or light grayish-brown loamy sand containing many light-colored quartz and dark-colored basalt grains, which give a pepper-and-salt appearance. In the virgin condition this layer is noncalcareous, and it generally remains so even after extended periods of irrigation. It is underlain to a depth of about 24 inches by generally browner, in places yellowish brown, more compact, mildly calcareous material that is otherwise similar. In some places the upper part of this layer contains no lime. The compact layer of accumulated lime, which extends to a depth of about 44 inches, consists of very light grayish-brown or almost white gritty loam or clay loam. There is a sprinkling of gravel through this layer as well as in the layer above. Accumulated lime appears in veins in cracks, and in a few soft spherical nodules. Below this, a bed of gravelly sand continues to an undetermined depth. The gravel is derived largely from light-colored quartzite, and the sand consists of an admixture of light-colored quartz and dark-colored basaltic particles. At greater depth coarse gravel and cobblestones appear.

The depth of the surface soil varies from place to place, and some areas are included in which the soil is thicker and the depth of leaching greater than in the typical soil.

The larger bodies of this soil lie across the river from Shelley, southeast of Springfield, and east of Fort Hall. The rest occurs as smooth basin areas in the sand-dune district north of Lower Presto School. Most of this land is farmed.

The surface is smooth and flat to gently undulating. Surface drainage is sufficient, internal drainage is rapid to excessive, and neither seepage nor concentration of salts has occurred. The relief is favorable for efficient distribution of water, and only minor scraping has been necessary in leveling. The water requirement is high, but the compact lime layer aids in the retention of moisture. If short runs and frequent irrigations are used, good yields are usually obtained.

Organic matter and nitrogen are decidedly deficient, and crop rotation including alfalfa or other legumes should be practiced in order to maintain fertility and to increase the moisture-holding capacity. The use of barnyard manure and the incorporation of other organic residues materially increase yields. The surface soil usually is sufficiently leached so that the availability of phosphate is not limited by excess lime.

Under proper management most of the crops of the area can be grown with satisfactory returns. Because of the sandiness of the surface soil, however, alfalfa for hay and seed, and potatoes are the most satisfactory. Alfalfa yields 3 to 4½ tons an acre of hay or 3 to 10 bushels of seed, and potatoes 225 to 330 bushels.

This light-textured soil is subject to some wind erosion, and care must be taken in cultivation not to accelerate this process. Alfalfa

has a stabilizing effect, and the land is often left in this crop for extended periods. With proper crop rotation and management erosion can be held to a minimum. After a number of years under irrigation, better granulation takes place and the materials are more stable.

Bannock sandy loam.—The 14-inch surface soil of Bannock sandy loam is light-brown or medium-brown sandy loam with a pepper-and-salt appearance from an admixture of dark-colored basalt and light-colored quartz particles. Gravel is scattered throughout. In the virgin condition this layer is leached, and in many places it remains free of lime even when irrigated. Below this is a layer of richer medium-brown loam that is slightly compact and contains scattered gravel. The compact lime layer lies between depths of 30 and 40 inches. It consists of light grayish-brown or brownish-gray heavy loam or gritty silty clay loam that contains gravel and nodules and veins of lime. This is underlain abruptly by sand and gravel strata, mostly dark basalt sand and light quartzite gravel. Coarser gravel and cobbles occur with increasing depth.

Bodies of this soil are widely scattered over the area, mainly bordering the upland and sand-dune districts. Most of the land is farmed.

The land is smooth and level to slightly undulating. Surface drainage is good, and internal movement of water is rapid. The compact lime layer increases the moisture-holding capacity of this sandy soil.

All the common crops of the area are grown on this soil, but alfalfa and potatoes give the most satisfactory yields and are preferred. Alfalfa yields from 3½ to 5½ tons of hay or 3 to 12 bushels of seed to the acre, potatoes 225 to 400 bushels, wheat 20 to 50 bushels, barley 20 to 55 bushels, oats 25 to 60 bushels, sugar beets 10 to 15 tons, peas 10 to 25 bushels, and beans 10 to 30 bushels.

This soil is deficient in organic matter and nitrogen, and a crop rotation including alfalfa or other legumes is necessary to offset these deficiencies. All available barnyard manure and other crop residues should be used to aid in keeping up the fertility. Because of the general deep leaching of lime in this soil, the availability of phosphate is not so retarded and the response to the addition of superphosphate fertilizer is not so marked as in the more calcareous soils. Addition of this element may become necessary, however, if irrigation has the effect of increasing the lime content.

The border method of irrigation for alfalfa and grains and the furrow method for intertilled crops are used. Short runs are usually the most satisfactory, and large heads of water are used to prevent excessive percolation and loss of water.

Bannock sandy loam, slope phase.—The slope phase of Bannock sandy loam covers a small total area, chiefly southeast of Springfield, southwest of Shelley, and in the vicinity of Moreland. Less than one-half of the land is farmed, because it lies too far from the supply of irrigation water by gravity.

This soil differs from the typical soil in the sloping to rolling relief and in the variability in thickness of the surface soil. In some places southeast of Springfield the soil is shallow and basalt outcrops. Irrigation is more difficult and less effective and yields are decidedly lower than on the typical soil. Erosion is easily accelerated, and, in order to prevent this, small heads of water should be used, and water should

be distributed by furrows that follow the contour of the land. Management to maintain fertility is similar to that for the typical soil, but more care is needed because of the lack of uniformity of the soil. Alfalfa for hay and seed is the favored crop. Yields are about one-third less than on the typical soil.

Bannock fine sand.—To a depth of about 18 inches Bannock fine sand is light-brown or medium-brown fine sand or medium sand, noticeably darkened by a large proportion of basalt sand grains, which give a pepper-and-salt appearance. The sand is loose and contains a scattering of gravel. It is leached and rarely has any appreciable lime content after being under irrigation. It is underlain to a depth of about 40 inches by browner more compact material consisting of moderately calcareous gritty loam. Gravel is sprinkled throughout this layer. In some places the top of this layer is free of lime. Between depths of 40 and 48 inches is the layer of accumulated lime. This material is light grayish brown or light brownish gray. This soil contains more gravel than do the other Bannock soils, as it rests on a substratum of loose sand and gravel. The gravel consists largely of light-colored quartzite, and in many places lime and silica coat the pebbles or their under sides. The sand is coarse and consists predominantly of dark basalt grains rounded by the action of water.

Most of this soil occurs in the sand-dune district north of Lower Presto School, where it occupies long, narrow, smooth areas and small basins among dunes or ridges of sand. The aggregate area is not large. This is an important soil, as in many places it is the only tillable soil in this large district consisting so largely of unstable sand. About three-fourths of the total area of this soil is farmed.

The surface is flat and smooth in the basins to level and gently undulating in the long areas between the sand ridges. Included are a few bodies, bordering the dunelike and hummocky areas, that have an uneven, somewhat rolling surface. Such areas are seldom farmed, but they offer possibilities for development. Some of the land now irrigated formerly had an uneven surface before it was leveled for cultivation, and many of the smooth basins have been enlarged by leveling the more uneven edges. On the other hand, many areas now cultivated are being reduced by the encroachment of wind-blown sand. It is important to keep the surrounding dunelike areas stable. Generally the native vegetation is inadequate for this purpose, and a cover of straw or manure must be used.

Although the sand is very porous and droughty, the compact layer of accumulated lime aids materially in holding moisture. Sufficient irrigation water is available to supply the needs for the large requirement of water in crop production, and yields are fairly good where short runs and frequent applications are practiced. Success is varied, however, depending on the experience and skill of the farmer. The dike method of irrigation, supplemented by furrows, and with the use of large heads in order to distribute the water rapidly without excessive percolation and loss, meets with the best success.

Alfalfa is the most important crop and probably occupies three-fourths of the land. This crop largely prevents soil blowing, and it is often allowed to remain in the fields for many years because farmers are reluctant to destroy this protective cover. The growth of this crop continuously for many years incorporates organic matter, and

irrigation increases the stability of the material, making it then feasible to grow other crops. The moisture-holding capacity and the nitrogen content are also increased by this practice. Potatoes are grown in rotation as a cash crop and small grains as a nurse crop for alfalfa. The surrounding sand areas afford some pasturage, and livestock enterprises supply a considerable part of the cash income. Hay that is not fed to farm livestock is sold for winter feeding of range cattle and sheep.

Alfalfa yields 2½ to 4 tons of hay or 3 to 8 bushels of seed to the acre, potatoes 100 to 250 bushels, and wheat 5 to 20 bushels. Barley and oats give similar low returns.

The use of barnyard manure and other organic manures is essential to sustain satisfactory yields on this soil, from which mineral elements of fertility and organic matter and nitrogen are more quickly removed than from less sandy soils that inherently have a large content of plant nutrients.

Bannock fine sand, hummocky phase.—The hummocky phase of Bannock fine sand is a fairly extensive nonagricultural soil of the dune-sand district in the northern part of the area. A small part of it lies east of Woodville.

The lay of the land is uneven and is unsuited for irrigation, and the unstable blow sand is not suitable for tillage. Sparse coarse bunchgrasses, low shrubs, and a few flowering annuals afford some grazing. This soil, closely associated with the farmed basins and smoother areas, provides extensive pasture land for livestock, and considerable revenue is derived from livestock products.

This soil has a poorly developed or no profile. The sand, which has a medium-brown pepper-and-salt color, contains little or no lime to considerable but extremely variable depths, and the surface material is too unstable, and the penetration of water too rapid to allow an appreciable accumulation of lime.

Paul silty clay.—The 18-inch surface layer of Paul silty clay is rich medium-brown silty clay loam or silty clay that is sticky and plastic when wet but somewhat granular when moist. This layer contains little or no lime in the virgin condition, but it becomes calcareous through irrigation. It overlies lighter brown silty clay loam or silty clay, which has a very slight red tinge. It evidently contains less organic matter and is slightly heavier and more compact than the surface soil. This material is mildly to moderately calcareous and contains some lime veins at the bottom. It is underlain to a depth of about 30 inches by a layer of accumulated lime. The material in this layer is compact and very light brownish gray—in places has a slight red cast. Spherical lime nodules in closely packed masses are present. At a depth of about 65 inches there is an abrupt change to loose gravelly and sandy strata similar to those of the Bannock soils. The gravel consists of light-colored quartzite, in many places coated on the under side by lime and silica. The sand has a mixed pepper-and-salt appearance, owing to an admixture of dark-colored basalt and light-colored sand grains. These continue to an undetermined depth, with increasing coarseness of material.

This soil occurs in more or less continuous bodies north and southwest of Goshen. It occupies a low flat position between the sand

dunes and the gently sloping Ammon soils. All the land is under cultivation.

Paul silty clay has developed largely from deposits of fine water-laid materials over gravelly alluvium. As it occupies a low drainage trough, a comparatively luxuriant cover of vegetation has contributed some organic residues.

Although the surface is almost flat to gently sloping, the southwestward slope of the valley floor generally allows for escape of surface floodwaters. Water stands in a few small basins, however, in early spring and during irrigation. Penetration of water is slow, but the deeper underdrainage is rapid, and the water table is low enough so that no seepage or concentration of salts have developed. In a few places adjoining the Ammon soils a tight intractable soil suggests that some sodium saturation of the soil colloids exists. Yields of crops are said to be decreasing in these places.

All the common crops of the area are grown on this soil, although it is less productive for some crops, such as alfalfa, potatoes, and beans, than are the lighter textured, more friable soils. Small grains are especially well adapted. Alfalfa occupies about one-third of the area, wheat and small grains one-third, and the rest of the land is allotted to other crops commonly grown, especially potatoes. Alfalfa yields from 2½ to 4 tons an acre, wheat 40 to 80 bushels, barley 60 to 90 bushels, oats 60 to 110 bushels, potatoes 175 to 250 bushels, peas 15 to 40 bushels, and sugar beets 10 to 15 tons. Alfalfa seed is not produced.

This soil has a higher inherent fertility and a higher organic-matter content than the lighter colored soils, such as the closely related Bannock soils; but the heavy texture of the soil limits production of certain crops as indicated. Alfalfa seems less retarded than some other crops, probably because of its penetrating root system. Alfalfa grown on this soil has finer stems and grows shorter than on lighter textured soils. This crop is necessary in rotation to increase permeability and to keep the organic matter at a high level for fertility and good tilth. Available manure is usually applied, especially for sugar beets. When this treatment is supplemented by the addition of phosphate, large increases in yields are noted, especially of sugar beets and alfalfa.

Favorable moisture conditions are necessary in both plowing and cultivating. Under such conditions the soil granulates remarkably for such a heavy-textured soil. In fields that are not cultivated, such as fields of alfalfa and small grains, deep cracks penetrate downward as the soil dries after irrigation. The furrow method of irrigation for intertilled crops and the border method for alfalfa and small grains are practiced.

Paul silty clay loam.—Paul silty clay loam borders Paul silty clay in long, narrow bodies north and south of Goshen. This soil differs from Paul silty clay in having a somewhat lighter textured surface soil and in being thinner over the gravel strata. The comparable horizons are likewise thinner but are otherwise identical. In places some gravel is present in the surface soil and in the material below. As the surface is very gently sloping at the edge of the flatter drainage depression occupied by the silty clay, surface run-off is more complete.

Irrigation water also penetrates more effectively and moves through the soil material more freely than in that soil. This soil is free from seepage and an accumulation of salts.

The total area is small. All the land is farmed and like Paul silty clay, this soil has good granulation, and because of its lighter texture it is more favorabe than that soil for alfalfa and potatoes and produces the other crops equally well. Alfalfa yields 2½ to 4½ tons an acre, potatoes 225 to 300 bushels, wheat 40 to 80 bushels, barley 60 to 95 bushels, oats 60 to 110 bushels, sugar beets 10 to 16 tons, and peas 15 to 40 bushels.

Paul loam.—Typically developed Paul loam consists of medium rich-brown loam to a depth of 14 to 16 inches. A small quantity of gravel is scattered throughout the soil material in most places. In the virgin condition this surface layer contains little or no lime, but it becomes calcareous under irrigation. Below this a layer of medium-brown more compact heavy loam or clay loam continues to a depth of about 24 inches. This layer has vertical cracks and breaks up into angular blocks. This layer ordinarily does not contain lime. It is underlain to a depth of about 32 inches by lighter, slightly reddish, medium-brown clay loam containing some accumulated lime. This material is compact and brittle. It rests on the layer of accumulated lime, which continues to a depth of about 60 inches. The material in this layer is very light brownish gray and contains veins and spherical nodules of lime and some lime-coated gravel. Generally the lime layer changes abruptly to the loose gravelly strata, but in places it contains clayey intermixtures for several feet above these strata. The deeper strata consist of light-colored quartzite gravel loosely bedded with pepper-and-salt sand.

This soil is closely associated with the other Paul soils in the vicinity of Goshen. It is all farmed.

The land is level to gently sloping, and surface and internal drainage are good. The moisture-holding capacity is very good. Effective irrigation is possible because of the smooth surface. The border method for alfalfa and grains and the furrow method for intertilled crops are usually employed.

This soil is favorable for a wider range of crops than the heavier textured soils of the Paul series. Alfalfa yields 3 to 5 tons an acre (pl. 1, *B*), wheat 30 to 75 bushels, barley 55 to 95 bushels, oats 55 to 95 bushels, potatoes 225 to 400 bushels, sugar beets 12 to 16 tons, and peas 15 to 35 bushels.

This soil can be managed effectively under a wider range of conditions than the heavier textured soils of this series, but a similar rotation is followed on all these soils. As in other soils of this area, the organic-matter content needs to be increased and maintained by the use of legumes and organic manures, in order to promote good tilth, to increase the moisture-holding capacity, and to insure an adequate supply of nitrogen.

As mapped, some variation occurs in the thickness and sequence of the soil horizons, and a body of a shallow gravelly soil about 1 square mile in size and associated with the other Paul soils north of Goshen is also included. The surface of this area is not so smooth as that of the typical soil, and limy spots are exposed as a result of leveling. Likewise, the distribution of water is not so effective as on the typical

soil, and the soil does not hold water so well. Although the same crops are grown, yields are about one-third less than those obtained on the normal soil.

Paul sand.—Paul sand, an inextensive soil, lies in a transitional area between the sand dunes and the other Paul soils. Drifting sands from the dunes have materially modified this soil, both in depth of surface soil and in relief. The land ranges from smooth and level to undulating, and a few small hummocks occur on the areas not farmed. Considerable leveling has been necessary in order to bring this soil under cultivation. About three-fourths of the land is farmed. It is subject to wind erosion, and alfalfa is the principal crop because it keeps the sand from blowing and adds needed organic matter to the soil. Manure, where available, is used in addition. Large heads of water and short runs are necessary in order to distribute the irrigation water evenly. Alfalfa occupies more than three-fourths of the cultivated land. Potatoes are the principal cash crop, and a few other crops are grown. Alfalfa and potatoes yield one-fourth to one-third less and other crops one-third to one-half less than on Paul loam.

Rupert fine sand.—The surface soil of Rupert fine sand consists of grayish-brown loose medium sand or fine sand, made up largely of a pepper-and-salt mixture of light-colored quartz and dark-colored basalt particles. This is underlain at a depth of about 8 inches by a layer of slightly browner open, permeable, and very slightly compact material that is otherwise similar to the surface soil. Below a depth of about 20 inches the material is looser and somewhat more yellowish brown. This rests on gray loose sand containing a large proportion of black basaltic grains. The surface soil and upper part of the subsoil generally contain no lime, and the deeper material is either noncalcareous or in places mildly calcareous.

The land is smooth and flat to gently undulating and is favorable for the distribution of irrigation water, although, because of the loose, porous character of the soil, large heads of water and short runs should be used, in order to avoid excessive loss by deep percolation. Most of this soil lies within the Fort Hall Indian Reservation. About three-fourths of the total area is farmed.

This is a soil of low moisture-holding capacity. Alfalfa seed is the only crop grown successfully. Water is plentiful during the short irrigation season for this crop, and it can be applied without danger of oversaturation, a condition that causes excess vegetative growth at the expense of the seed. Most of this land has been in cultivation only a few years, and no lime has accumulated to limit the availability of phosphate. Likewise, diseases and insect pests that harbor in the soil and debris have not become very prevalent. Alfalfa usually yields 3 to 12 bushels of seed, although higher yields have been reported.

Rupert fine sand, rolling phase.—In the virgin condition, Rupert fine sand, rolling phase, has a surface layer about 8 inches thick, of dull medium-brown or grayish-brown loose medium sand to fine sand containing an admixture of dark-colored basalt and light-colored quartz particles, which give it a pepper-and-salt appearance. It contains no lime and has a sprinkling of gravel. This material overlies a layer of richer, medium-brown, slightly more compact loamy sand

having the same pepper-and-salt appearance. This layer also is noncalcareous and sprinkled with gravel. Between depths of 20 and 32 inches the material is less compact than above and consists of slightly yellowish medium-brown sand or loamy sand, in which the pepper-and-salt appearance is very pronounced. Like the layers above, this layer is slightly gravelly and leached. It rests abruptly on dark loose sand in which black basalt sand grains make up about half of the soil mass. This material is mildly calcareous and contains a small quantity of quartzite gravel, which becomes more plentiful at a depth of 12 to 15 feet or more. Below this depth, strata of coarser material including cobblestones continue to an undetermined depth.

About 11 square miles of this soil is mapped, almost entirely within the Fort Hall Indian Reservation. Almost none of it is farmed, because its uneven surface makes it unsuited for irrigation in most places. The sparse grass and brush afford some grazing.

The undulating to rolling surface is broken in many places by low hummocks formed by the unstable shifting surface sand lodging around the sparse vegetation.

The soil has a low moisture-holding capacity. Most of the areas are excessively drained, although deep percolation appears to be retarded in some areas near the stream bottoms west of Fort Hall, where there is evidence of some accumulated seepage. On the south it merges and joins with the Winchester fine sand of the earlier soil survey of the Portneuf area (*7*).

Rupert fine sand, dune phase.—Rupert fine sand, dune phase, occupies the sand-dune district in the Fort Hall Indian Reservation. It occurs as dunes and ridges on which only a sparse growth of bunchgrasses and brush survives. Except for the scant grazing it affords, this is a nonagricultural soil. The aggregate area is fairly large.

Shifting surface sands lodge around the vegetation, in many places burying it. As most of this soil is isolated, the drifting sand does not endanger any farmed areas. The soil color is the same as in the typical soil, the pepper-and-salt appearance being very noticeable. This soil in few places has any distinct layers. Gravel is scattered throughout all but the higher dunes. Benchlands and hills to the east are mantled with sand, and the valley floor to the northeast is in part buried by dunes.

In some of the areas, this soil can be distinguished only with difficulty from the Winchester soils, and it joins with Winchester fine sand of the earlier soil survey of the Portneuf area on the south (*7*).

Rupert gravelly loamy sand.—In the virgin condition, the 6-inch surface layer of Rupert gravelly loamy sand is medium grayish-brown noncalcareous very gravelly loamy sand having a pepper-and-salt appearance from mixture of dark-colored basalt sand and light-colored quartz particles. The material breaks up into very soft fragile clods or slightly coherent masses. This overlies somewhat more compact medium-brown sandy loam that also has a pepper-and-salt appearance and contains a large quantity of gravel. Between depths of 18 and 36 inches the material is slightly lighter colored than above, in many places having a yellow cast, and consists of noncalcareous very slightly compact gravelly sandy loam. This rests on loose, very porous beds of gray gravelly sand containing a large proportion of light-colored quartzite gravel. The material is definitely calcareous but free from

lime cementation or compaction. Many pieces of gravel are coated with lime and silica on the under side. This bedded gravel continues to an undetermined depth, generally becoming coarser and including cobbles with increase in depth.

The quantity of gravel varies somewhat from place to place, and some small areas are included in which there is only a scattering in the surface soil. Small areas of lighter textured sandy soil are also included in mapping.

This soil lies almost entirely within the Fort Hall Indian Reservation. It occupies an area of about 6½ square miles. Only a very small part is farmed.

The land is smooth and nearly level to slightly undulating. Surface drainage is good, and internal drainage is excessive. The moisture-holding capacity is very low, although slightly better than in Rupert fine sand. The lay of the land, comparable to that of Rupert fine sand, is favorable for the distribution of water; but this is not considered so good a soil because of its high content of gravel. Only a few small areas are producing alfalfa seed at present. Yields are about the same as on Rupert fine sand.

Winchester sand.—Like the other Winchester soils, Winchester sand is definitely of wind-laid origin, as no gravel occurs above the basalt substratum. Lying east of the Rupert soils at a higher elevation, it is probably developed from sand blown from those soils. Most of this inextensive soil lies within the Fort Hall Indian Reservation.

Winchester sand has no distinctly developed layers. In the more representative areas the surface soil consists of dull dark grayish-brown sand, much of the dark color being due to black basalt particles, which make up about half of the mass and give it a striking pepper-and-salt appearance. This color is predominant to a depth of about 10 inches, where the soil material becomes slightly lighter colored. The soil materials are generally noncalcareous to a depth of 6 feet but are slightly calcareous in places. Below this depth, lime is accumulated in places and the soil materials are grayer than they are above.

The land is undulating to rolling, and low hummocks are formed by sand lodged around clumps of the sparse vegetation. Coarse bunchgrasses, low desert shrubs, and some flowering annuals survive in the shifting sand. This soil affords some pasturage, but it is not suitable for cultivation.

Winchester sand, dune phase.—The dune phase of Winchester sand occurs principally along the eastern edge of the area in the Fort Hall Indian Reservation. The sparse vegetation of coarse bunchgrasses and low brush afford some grazing; otherwise it is a nonagricultural soil.

The shifting sand has no distinctly developed layers. The relief is dominated by pronounced ridges and dunes conforming somewhat to the form of the underlying lava beds. The immediate surface is marked by low hummocks of sand accumulated around the sparse vegetation.

SOILS OF THE BOTTOM LANDS AND DEPRESSIONS

The soils of the bottom lands and depressions occupy only a small part of the Blackfoot-Aberdeen area, but certain of these soils contribute materially to the cultivated acreage, especially in the vicinity

of Blackfoot and northward along the Snake River. Perhaps about one-half of the land is tillable; the rest is used for native pasture and hay. Some of these soils were the earliest settled and farmed, because water for irrigation could be diverted easily and the inherent fertility of the soils is high. Those with sufficient natural moisture produced native hay and pasture, essential in the pioneer agriculture. Much of the tillable soil remains the most productive in the area, but subsequent irrigation on higher lying contiguous lands has caused excessive seepage and accumulations of salts in certain places, reducing the cultivated acreage. In some places seepage has improved the pasture and the production of native hay, but in most places it has reduced the quality of the hay and pasturage because of excess moisture and accumulation of salts.

Most of these soils occupy low flood plains along the Snake and Blackfoot Rivers (see fig. 2, p. 5), but some soils, especially those of the Blackfoot series, lie in small depressions and basins of the terraces that are affected by seepage or imperfect drainage.

Most of the members of this group are dark gray or dark brown as a result of a comparatively high organic-matter content, developed from a more luxuriant vegetation than occurs on the lighter colored well-drained soils. These soils are inherently more fertile than the lighter colored soils because of the higher content of organic matter and nitrogen and because fresh mineral and organic materials have been deposited by water. The Beverly soils, however, are light-colored, are well drained, and do not contain much organic matter. In order of increasing darkness and humus content, the other soils of this group are Blackfoot, Onyx, Gooch, Snake, and Logan.

The Beverly and Blackfoot soils, and, to less extent, the Onyx, representing about two-thirds of the area of the bottom lands, contribute a valuable acreage for the production of crops. The Snake, Gooch, and Logan soils are not cultivated and produce only native hay and pasture.

The Beverly soils are light-brown or light grayish-brown soils containing gravel in various quantities. In color and low humus content they are similar to the gravelly soils of the valley floor, which they adjoin. They do not have an appreciable accumulation of lime or clay in the subsoil; they are affected by drought, and they need phosphate fertilization, especially for alfalfa, sugar beets, and clover seed. They occur along the Snake River from Ferry Butte northward and are extensively farmed. More than half of the tillable area of bottom lands is covered by these soils. They have a smooth surface favorable for irrigation, and irrigation water is plentiful.

The Blackfoot soils are deep medium-brown or dark grayish-brown calcareous soils containing considerable organic matter. They are very productive for most crops. Surface drainage is fair, and the moisture-holding capacity is excellent. Underdrainage is good except in the poorly drained phases, as the water table stands low enough in the gravelly substratum to take care of excessive water from irrigation. The smooth nearly level surface is favorable for irrigation, and the water supply is sufficient to mature crops. Gravel nowhere appears in sufficient quantity to interfere with cultivation. About one-third of the area of the cultivated bottom lands consists of these soils. The poorly drained phases of the Blackfoot soils have

calcareous surface soils and upper subsoil layers similar in color and humus content to the corresponding layers of the typical Blackfoot soils, but these layers are free of gravel and the lower subsoil layers are heavier textured, in many places containing strata of clay. The deeper substratum is bedded with clay, which restricts free movement of water, and waterlogging occurs in places, especially east of Blackfoot and in the vicinity of Sterling. Here, surface water and salts have accumulated, so that most of the cultivated acreage has been abandoned to saltgrass pasture. The best drained and most extensively cultivated of these soils lie east of Lower Presto School. The rest of the cultivated acreage occupies small basins and smooth long narrow areas in the sand-dune district southwest of this school. Here the water table is high and fluctuates with the irrigation season. This locality originally was known as the Sand Creek sinks. Although this stream no longer has a distinct channel, it still contributes materially to the excess water that accumulates.

The Onyx soils are inextensive, being represented by only one soil type, most of which lies south of Fort Hall. All this land is farmed. The surface soil is browner than that of the Blackfoot soils and generally contains little or no lime, although under cultivation it has become mildly calcareous. In most places the subsoil is browner than the surface soil, friable, and permeable. This soil has a sprinkling of gravel throughout but not in large enough quantity to alter the methods of management or the moisture-holding capacity. Its productivity is about the same as that of the Blackfoot soils.

The nonarable soils of the bottom lands are members of the Gooch, Logan, and Snake series. The Gooch and Logan soils are dark brownish gray and highly organic; the Snake soils are medium brownish gray and comparatively low in organic matter. They all have imperfect or poor drainage, the water table being at or near the surface. In most places salts have not accumulated in sufficient quantities to prohibit growth of plants, although discernible quantities occur in the Snake soils.

The Gooch and Logan soils produce heavy yields of native hay and pasturage, but the grasses in many places are coarse, and coarse reeds and rushes flourish on the marshy areas. The Logan soils are darker in the surface soil than the Gooch. The former have light-colored stained and mottled subsoils of puttylike highly calcareous clay or silty clay; the latter have light-gray limy silty clay subsoils that have a granular or mealy structure and, in the lower part, calcareous plates. A peculiar greenish-gray coloration, a result of poor drainage, is prominent. Of the soils used for native hay, the Gooch are the most extensive and important. They occur almost entirely within the Fort Hall Indian Reservation.

The surface soils of members of the Snake series are a lighter brownish gray and are lower in organic matter compared with the surface soils of the Gooch and Logan soils. The subsoil consists of light-gray mealy, limy, silty clay in the upper part and plastic but friable and permeable material in the lower part, which in many places contains accumulations of lime, as does the corresponding layer of the Gooch soils. The Snake soils generally do not produce luxuriant enough stands of native grass to justify cutting for hay but afford good pasturage.

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Beverly loam.—The surface soil of Beverly loam, to an average depth of about 12 inches, is light grayish-brown friable, mellow, fine-textured loam. This material generally is slightly calcareous, but in places it contains no lime under virgin conditions. This layer overlies stratified very slightly compact fine sandy loam that is light grayish brown when moist and light gray when dry. This layer generally is mildly calcareous, but the lime is disseminated and is discernible only by test with acid. A sprinkling of gravel occurs in both layers. Below a depth of 26 inches are loosely stratified sands and gravel, which continue to an undetermined depth but overlie basalt bedrock. The quartzite gravel is light-colored, but the sand contains a high proportion of dark-colored basaltic particles. In places the gravel is coated with lime and silica, but this appears not to have developed in place.

This soil is extremely variable from place to place in depth of both the surface soil and the underlying materials above the gravel. The content of gravel also varies considerably. Some slight lime and clay concentrations have developed in those areas on terrace levels that represent a transition to the Bannock soils. The areas of least modified and most droughty soil are just above the river.

Small bodies of Beverly loam are scattered along the Snake River from Ferry Butte northward. It is one of the better soils of this series, and practically all of it is farmed.

The land is smooth and nearly level to very gently undulating. Surface drainage is good, and internal movement of water is very rapid. Because of the lack of any appreciable lime or clay concentration in the subsoil, the moisture-holding capacity is low. Sufficient water is available, however, for the frequent irrigations that are necessary, especially on the areas of thinner and more gravelly soil.

The crops grown and the rotation followed are about the same as for the Bannock soils, with which this soil is closely associated in many places. About one-third to one-half of the land is in alfalfa, one-fourth in wheat and other small grains, and the rest in such cash crops as potatoes, sugar beets, and peas. Alfalfa yields 2½ to 4 tons an acre, wheat 30 to 60 bushels, barley 30 to 65 bushels, oats 30 to 70 bushels, potatoes 175 to 250 bushels, sugar beets 8 to 12 tons, peas 15 to 30 bushels, and beans 10 to 25 bushels.

This soil has the same deficiencies in organic matter and nitrogen as other light-colored soils, and crop rotation including alfalfa or other legumes is followed to build up and maintain the productivity. Barnyard manure and other organic residues are of marked benefit, as they also increase the moisture-holding capacity, which is naturally low. This soil shows decided response to application of phosphate, especially for alfalfa and sugar beets.

The border method of irrigation for alfalfa and small grains and the furrow method for intertilled crops are practiced. Short runs and large heads of water are necessary on the areas of shallower and more porous soil.

A number of small scattered bodies along the Snake River closely associated with the typical soil and aggregating about one-half square mile differ from the typical soil in having a shallower surface soil and a high content of gravel. These areas are shown on the soil map by gravel symbols. A few basins and scraped spots in which the soil

has a heavier texture also are included. The moisture-holding capacity and the fertility are lower than in the typical soil, and the soil is also more difficult to plow and cultivate because of the high gravel content. Since irrigation water is plentiful, fair success can be obtained with short runs and large heads of water. A careful crop rotation including legumes and the supplementary use of barnyard manure are necessary for satisfactory continuous production. The crops grown are the same as on the typical soil, but yields are about one-third less.

Beverly silty clay loam.—To a depth of about 12 inches Beverly silty clay loam is grayish-brown to light grayish-brown friable and somewhat granular silty clay loam. This material generally is slightly to mildly calcareous. It is underlain by light grayish-brown slightly compact but friable loam or fine sandy loam of a mellow consistence. This layer is mildly calcareous and contains a scattering of gravel. It gives place abruptly at a depth of about 28 inches to light grayish-brown loose stratified sand and gravel with a pepper-and-salt appearance from a high content of dark basalt sand and lighter colored particles. Lime coating appears in places on the gravel, but apparently this is rarely developed in place, although in some places lime seems to collect where the fine materials give way to more porous strata.

This soil occupies lower lying areas below the terrace breaks and small basins, and it is generally more uniform and deeper over the gravel strata than are the other Beverly soils. In these flat back-bottom positions surface run-off is slow, but, because of the permeable subsoil, water percolates downward rapidly. A few drainage depressions also occur where the land is slightly sloping. The generally flat surface allows an even distribution of irrigation water, and the moisture-holding capacity is better than that of the other Beverly soils. This is the most productive soil of the Beverly series.

Long, narrow bodies of this soil border the Snake River from the vicinity of Riverside north to Firth. All the land is farmed.

Alfalfa yields 3 to 4½ tons an acre, wheat 35 to 65 bushels, barley 30 to 70 bushels, oats 30 to 75 bushels, potatoes 175 to 250 bushels, sugar beets 8 to 14 tons, and peas 15 to 35 bushels.

Crop rotation including alfalfa or other legumes is essential in order to build up and maintain organic matter and nitrogen. Barnyard manure adds materially to the productivity. Phosphate has been proved to give marked increases in yields of alfalfa and sugar beets. Alfalfa and small grains are irrigated successfully by the border method and intertilled crops by the furrow method. There is practically no erosion on this soil.

Beverly very fine sandy loam.—Beverly very fine sandy loam, to a depth of about 10 inches, is light-brown or light grayish-brown mellow friable very fine sandy loam that in places contains no lime but generally is mildly calcareous. This overlies light grayish-brown slightly compact fine sandy loam that is moderately calcareous but shows no accumulation of lime. This gives way abruptly, at a depth of about 24 inches, to loose, porous, stratified sand and gravel. In places the gravel has a lime coating. The sand has a pepper-and-salt appearance, due to a high content of dark-colored basalt and light-colored quartz grains.

There is great variability in the depth of soil material over the gravel. Although the average soil shows a scattering of gravel throughout, the content varies greatly from place to place. Small areas in which the soil ranges from very fine sandy loam to sandy loam are included in mapping.

Bodies of this soil are scattered along the Snake River from the vicinity of Riverside to Woodville. They aggregate a fairly large area. Most of the land is farmed.

The surface is smooth and nearly level to very gently undulating and favors uniform distribution of irrigation water. The soil absorbs water readily, internal movement of water is very rapid, and underdrainage is excessive. The moisture-holding capacity is low, and frequent irrigation is necessary in order to maintain uniform growth. Sufficient irrigation water is available to mature all the crops commonly grown.

The crops grown and their distribution are about the same as on the other Beverly soils. Alfalfa yields 2½ to 4 tons to the acre, wheat 20 to 55 bushels, barley 25 to 60 bushels, oats 20 to 65 bushels, potatoes 125 to 250 bushels, sugar beets 6 to 12 tons, and peas 10 to 25 bushels.

This light-textured soil requires care in cultivation, as it is susceptible to wind erosion and, in less degree, to water erosion. It is essential to build up the organic-matter content, by growing alfalfa or other legumes and applying organic manures, to control erosion and offset organic and nitrogen deficiencies. Alfalfa affords good cover for stabilizing the soil against wind erosion, and it often occupies the fields for many years. The content of available phosphate is low, and application of this fertilizer is necessary for satisfactory yields of alfalfa and sugar beets.

Short runs and comparatively large heads of water are used in irrigation. The border method for alfalfa and grains and the furrow method for intertilled crops are the most satisfactory.

Beverly very fine sandy loam, gravelly phase.—Only a small total area of the gravelly phase of Beverly very fine sandy loam is mapped. Small bodies are widely distributed in association with bodies of the typical soil, and most of them are farmed in conjunction with that soil.

This soil differs from the typical soil in having a high content of gravel throughout. Small areas are included that have a much thinner soil over the porous gravelly strata. These differences and variations from the typical soil make crops less uniform and materially reduce the yields. The water requirement is greater than for the typical soil. The more gravelly areas are difficult to plow and cultivate. Crop rotation including alfalfa or other legumes maintains the fertility to a fair degree, but barnyard manure is needed to increase both productivity and moisture-holding capacity. Application of phosphate also is necessary for sustained yields of alfalfa and sugar beets, and it benefits many other crops. About the same crops are grown as on the typical soil, but yields are about one-third less.

Beverly gravelly fine sand.—Beverly gravelly fine sand, an inextensive soil, is closely associated with Beverly very fine sandy loam along the Snake River in a few small bodies. About half of the land is farmed. Gravel bars entirely cover many of the bodies. Such bodies have little or no soil cover and seldom mature crops satis-

factorily because of the lack of fertility and sufficient moisture-holding capacity. Such bodies are used only for pasture, but the carrying capacity is very low; others near the river are overflowed during high water. The water requirement is high, and where this soil is isolated from better producing soils it is not farmed because returns are too small for the expense involved. Many crops fail, but where they do mature they return yields about one-half as high as those on Beverly very fine sandy loam.

Beverly fine sand.—Only a small total area of Beverly fine sand is mapped, mostly adjacent to the Snake River flood plain and the other Beverly soils. It is very similar to Beverly very fine sandy loam but is sandier and more variable as to thickness and texture of the surface soil and as to gravel content. Although dominantly of fine sand texture, there are numerous included areas of sand, as well as some areas that are gravelly, and a few hummocky or dunelike areas. Surface materials are very loose, and the vegetation is too sparse to offer much protection against blowing. None of this soil is farmed, but some pasturage is available—brush, browse plants, and scattered bunchgrass.

Beverly fine sand, eroded phase.—The eroded phase of Beverly fine sand lies near the Snake River channel. It has an irregular relief broken by numerous abandoned stream channels, and, although a fair soil cover generally overlies the gravelly strata, it is interrupted in many places by sand and gravel bars. Wind and water erosion have created an uneven depth of surface soil; nevertheless this layer is deeper and less gravelly than that of Beverly gravelly fine sand. Because of the uneven surface and the unfavorable position near the river, this soil is not farmed. It provides some pasturage, but the vegetation is very limited, being mostly sagebrush. Cottonwood, willow, and brush grow along the stream channels. High water in the spring frequently inundates or isolates this land. The total area is small.

Blackfoot loam.—To a depth of about 10 inches the surface soil of Blackfoot loam is dull grayish-brown calcareous granular friable loam having a somewhat silty texture. It contains a scattering of gravel. This layer is underlain by granular to cloddy clay loam that is dull grayish brown with some bluish-gray and rust-brown colloidal stains. This material is highly calcareous and contains a sprinkling of gravel in most places. Between depths of 20 and 48 inches there is a stratified layer of clay loam that is more permeable and lighter colored than the material above and decidedly gray when dry. This layer is more calcareous than the layers above. Gravel is present in small quantities. This layer, in turn, rests on lighter grayish brown or brownish-gray stratified material ranging from silty clay loam to sand and gravel. There is considerable mottling and colloidal staining. The porosity and the quantity of stratified sand and gravel increase with depth, and below a depth of 7 to 8 feet the material is generally very porous and gravelly. Small spiral shells are numerous in the subsoil and substratum.

Under irrigation and moist conditions of spring and fall, this soil is considerably darker than it is in the dry condition. Minor varia-

tions in the gravel content occur. A few areas of more gravelly character than average are north of Ferry Butte.

Large and small bodies of this soil border the Blackfoot River from the vicinity of Blackfoot to Ferry Butte and southward along the Snake River. The total area is fairly large. A third of it lies within the Fort Hall Indian Reservation. All the soil along the Blackfoot River is farmed.

The land is smooth and level to slightly sloping. Surface drainage is sufficient to take care of excess water from all sources, including that from irrigation. Internal drainage is somewhat slow but is sufficient to prevent waterlogging. The soil holds moisture well enough to mature crops without the use of a very large quantity of water for irrigation.

Most crops of the area are grown on this soil. It is productive for all crops but is especially favorable for garden and truck crops, small grains, and sugar beets. Seed peas are grown very successfully, and the acreage in this crop is increasing. The soil is a little cold in the spring for the highest production of alfalfa, but it usually returns good yields, ranging from 2½ to 4 tons an acre. Wheat yields 35 to 70 bushels, barley 35 to 80 bushels, oats 40 to 100 bushels, potatoes 175 to 250 bushels, sugar beets 12 to 20 tons, and peas 25 to 50 bushels.

Like the other Blackfoot soils, this soil was among the first soils farmed in this section, and probably it has been in cultivation more than 50 years. Continual cultivation has drawn heavily on the plant nutrients and has somewhat depleted the organic matter, so that the fertility and tilth are not so good as they were originally. Farmers report reduced yields and greater difficulty in maintaining proper tilth. Even where proper crop rotation, including alfalfa or other legumes, has been carried on, productivity and ease of cultivation have been reduced. The use of available barnyard manure and other organic and green manures is recommended. Seeding sweetclover with small grains and possibly with peas is an excellent practice. When plowed under the following spring, this adds considerable organic matter and nitrogen, improves permeability and tilth, and, in process of decaying, releases previously nonavailable phosphate and other elements.

In irrigation both the border and furrow methods are used as in the other soils of the area. On the heavy-textured Blackfoot soils it is possible to promote better aeration and tilth by growing row crops in high ridges above the furrows where the soil becomes hard and baked after irrigation.

Blackfoot loam, poorly drained phase.—The poorly drained phase of Blackfoot loam, to an average depth of about 12 inches, is dark grayish-brown calcareous granular loam matted with grass roots where not cultivated. It is underlain to a depth of about 28 inches by lighter grayish brown highly calcareous heavy loam or gritty silty clay loam containing some rust-brown mottling and becoming light gray when dry. The material is plastic when wet, yet fairly friable. Below this and continuing to a depth of about 65 inches are light-gray highly calcareous stratified clayey materials with sand and fine sand inclusions. This layer has considerable rust-brown staining and mottling. Small shells are common in this layer and in the substratum. The underlying materials vary considerably from place to place, but

they increase in permeability with increase in proportion of sand and gravel, also with increase in depth.

On the Sterling terrace this soil has dense blocky clays in the subsoil and substratum. These continue to an undetermined depth. These clays are mottled and discolored from poor drainage. Areas lying east of Lower Presto School have more friable subsoils than elsewhere.

This soil is widely distributed along the Blackfoot River and on the Sterling terrace, but the aggregate area is small. Less than one-half is in comparatively well drained positions favorable for cultivation. All the soil on the Sterling terrace is used for pasture. The principal vegetation is saltgrass, and only tules, rushes, and reeds grow in the more marshy areas. East of Blackfoot are similar salt-affected areas that are used only for pasture. Along the Blackfoot River some wild hay is produced. The larger part of the farmed area is east of Lower Presto School, in a better drained locality where the water table stands well below the subsoil. Crops grown and management practiced on this soil are very similar to those on typical Blackfoot loam. Similar yields are obtained on the two soils.

Blackfoot silty clay loam.—The surface soil of Blackfoot silty clay loam, to a depth of 12 to 14 inches, is dull medium gray-brown calcareous granular silty clay loam. It is underlain to a depth of about 50 inches by lighter brownish gray calcareous silty clay containing stratified layers. This material breaks into angular blocks wth colloidal coatings that are pale bluish gray when moist and have yellow and rust-brown mottlings and stains in places. This layer overlies stratified sand and gravel that contain small shells, fragments of shells, and rust-brown iron stains. The porosity of this material increases with depth. Gravel occurs in few places in the surface soil.

As in the other Blackfoot soils, the moisture content materially alters the color of this soil, and it is much darker when wet than when dry. A few small areas in which the surface soil is silty clay are included, and a larger area of silty clay lies directly across the river south of Blackfoot.

About one-fourth of the land lies within the Fort Hall Indian Reservation. It is all farmed.

In general, the land is almost flat, but it has a slight slope toward the river. Run-off takes place rather freely, although it is somewhat slow in places, and, as the internal movement of moisture is slow, the soil remains wet and cold later in the spring than the other Blackfoot soils.

This soil is too heavy and cold to be most desirable for such crops as alfalfa and potatoes, but the other crops of the area are grown successfully. Alfalfa yields 2 to 3 tons an acre, wheat 35 to 70 bushels, barley 35 to 80 bushels, oats 40 to 100 bushels, sugar beets 10 to 18 tons, peas 25 to 50 bushels, and potatoes 125 to 225 bushels.

Successful plowing and cultivation of this soil require favorable moisture conditions. A poor physical condition from depletion of organic matter is more apparent than in Blackfoot loam, and farmers are finding this soil harder to manage each year. In addition to a crop rotation that includes alfalfa or other legumes, the usual practice, it seems essential that barnyard manure and all organic residues

be carefully conserved and applied regularly. Marked benefits can be obtained by plowing under green manures. Sweetclover can be seeded with such crops as small grains and peas in order to provide a green-manure crop the following spring. Decaying organic matter apparently helps to increase the availability of phosphate in the soil.

Both the border and furrow methods are used in irrigation. The furrow method should be favored so that plants can grow on the ridges above the flooded furrows in which the soil becomes baked.

Blackfoot silty clay loam, poorly drained phase.—The surface soil of Blackfoot silty clay loam, poorly drained phase, to a depth of about 10 or 12 inches is dull dark grayish-brown calcareous silty clay loam having a granular structure. Under a cover of native grass this contains many grass roots. It is underlain to a depth of about 26 inches by lighter grayish brown moderately calcareous plastic but somewhat granular silty clay loam that is sticky and plastic when wet and contains stratified bands and rust-brown iron stains. At a depth of about 60 inches this rests on clay and sand strata that are light grayish brown with rust-brown and bluish-gray mottlings. Below this the strata become more porous and open. Gravel generally becomes plentiful 8 to 10 feet below the surface.

Areas of this soil on the Sterling terrace have compact dense blocky clay strata in the subsoil and substratum. These are mottled rust brown and blue gray because of poor drainage. East of Lower Presto School the soil is slightly lighter colored, more friable, more open throughout, and deeper over the clay strata than elsewhere. This allows freer drainage, and only a few small areas have accumulations of salts.

Small bodies of this soil occur along the Blackfoot River and on the Sterling terrace; larger ones are east of Lower Presto School. They include the greater part of the cultivated area, which represents about one-half of the small total area.

Most of the cultivated land is smooth and gently sloping; the rest includes mainly small flat depressions that are poorly drained. Here the water table stands at or very near the surface. Most of these areas are charged with salts, and saltgrass is the principal vegetation, although tules, reeds, and sedges grow where there is more permanent surface water throughout the year. On some areas adjacent to the Blackfoot River where the native grass and other water-tolerant vegetation is more luxuriant, native hay is produced.

Crop selection for this soil is rather wide, but alfalfa and potatoes grow somewhat less successfully than most other crops because of the heavy texture of the soil. Recommended crop rotation and management practices are similar to those recommended for typical Blackfoot silty clay loam. Alfalfa yields 2½ to 3½ tons an acre, wheat 35 to 70 bushels, barley 35 to 80 bushels, oats 40 to 100 bushels, sugar beets 10 to 18 tons, potatoes 125 to 250 bushels, and peas 25 to 50 bushels. Native hay yields 1 to 1½ tons.

Drainage and reclamation of the more poorly drained areas are difficult because of the small size of the areas, their location in the sand-dune district east of Blackfoot, and because of the impermeable clays of the subsoil and substratum in the areas on the Sterling terrace.

Blackfoot fine sandy loam.—To a depth of about 14 or 16 inches Blackfoot fine sandy loam is dull grayish-brown calcareous granular mellow fine sandy loam containing scattered gravel. It is underlain

to a depth of about 46 inches by granular or blocky silty clay loam stratified with bands of fine sand. Dull rust-brown and bluish-gray mottling or staining occurs on the blocks and in stratification bands. Below this is a yellowish-gray or brownish-gray more porous predominantly clayey layer extending to a depth of about 60 inches. Like the layer above, this layer contains some gravel. It overlies porous and loose stratified sand and gravel, which continue to an undetermined depth.

As in the other Blackfoot soils, the color changes with the moisture condition and is darkest when the soil is wet. The gravel content varies in different places but is of little significance except in a few areas north of Ferry Butte.

This soil occurs in less continuous areas than the other Blackfoot soils but is closely associated with them. The aggregate area is not large. All the land is farmed.

The smooth and level to slightly sloping surface allows free run-off. Internal percolation is slow, however, so that the soil has a tendency to remain saturated and cold in early spring. It holds moisture well, and the water requirement is low. Underdrainage is sufficient, so that no waterlogging has developed.

This soil is highly productive for all the crops grown and is more favorable for alfalfa and potatoes than the heavier textured Blackfoot soils. Alfalfa yields 3 to 4½ tons an acre, wheat 30 to 65 bushels, barley 30 to 70 bushels, oats 30 to 75 bushels, potatoes 220 to 300 bushels, sugar beets 12 to 20 tons, and peas 20 to 40 bushels.

Although this soil has been under cultivation as long as the heavier textured Blackfoot soils and has suffered similar losses through cropping, the physical condition has not been so much impaired, because of its lighter texture. There is definite need, however, to build up and maintain the organic-matter content as in the other soils. This can be done by using barnyard manure, crop residues, and green manures.

Blackfoot fine sandy loam, broken phase.—The broken phase of Blackfoot fine sandy loam occurs only southwest of Ferry Butte along the Snake River, the greater part within the Fort Hall Indian Reservation. None of the land is farmed, because of the unfavorable relief and general inaccessibility. The total area is not large.

The land is uneven and is broken by numerous abandoned or overflow channels. The soil does not have very clearly defined layers and varies considerably from place to place. Gravelly areas and gravel bars occur here and there, and the depth of the surface soil varies considerably. The soil is generally unsuited for crop growing. A sparse growth of grasses and considerable brush and shrubs furnish some pasture and browse. A dense growth of willows and some cottonwoods, especially along the channels and in moist areas, serves as shelter for livestock.

Blackfoot sandy loam.—The surface soil of Blackfoot sandy loam to a depth of about 16 or 18 inches is dull grayish-brown friable sandy loam containing a large quantity of basalt fragments and a sprinkling of gravel. It is mildly calcareous. This is underlain to a depth of about 44 inches by light grayish-brown moderately calcareous gritty clay loam stratified with thin bands of lighter textured materials. This layer contains scattered gravel and some rust-brown

mottling. Below this is very light yellowish-gray or brownish-gray calcareous clay loam containing some gravel and stratified very fine sand and sand. This overlies very porous strata of gray gravel and sand that contain much dark basalt sand and are somewhat discolored or mottled. Small shells are numerous throughout the lower part of the subsoil and the underlying strata.

Most of the small total area of this soil lies immediately south of Blackfoot. It is all under cultivation.

The land is smooth and level to very gently sloping. Surface drainage is good. This soil absorbs moisture readily, but internal movement of water is slightly retarded by the heavier texture in the subsoil. The movement is more rapid, however, than in the heavier textured Blackfoot soils, and the soil warms more rapidly in the spring. Underdrainage is sufficient to allow free movement of water. The water requirement is low, and water for irrigation is plentiful. Irrigation by both the border and furrow methods is practiced.

All the common crops of the area are grown on this soil. Its productivity for the various crops is similar to that of Blackfoot fine sandy loam. Alfalfa yields 3 to 4½ tons an acre, wheat 30 to 65 bushels, barley 30 to 70 bushels, oats 30 to 75 bushels, potatoes 225 to 300 bushels, sugar beets 12 to 20 tons, and peas 20 to 40 bushels.

Because of the lighter textured surface soil, this soil does not become baked and so compact as the heavier soils of this series. Rotations including alfalfa and other legumes and the use of barnyard manure and green manures are necessary, however, to maintain organic-matter content, nitrogen content, and good tilth. Supplementary applications of phosphate are advisable, especially for alfalfa and sugar beets, as the high lime content has a tendency to limit the availability of phosphate.

Blackfoot sandy loam, poorly drained phase.—The 12- to 14-inch surface soil of Blackfoot sandy loam, poorly drained phase, is dark dull grayish-brown granular sandy loam containing a large quantity of dark-colored basalt sand. In grass-covered areas there is a matted sod of fine grass roots. The surface soil is highly calcareous. It is underlain to a depth of 30 inches by grayer sandy loam containing thin heavier textured stratified layers. This material is highly calcareous and somewhat mottled with iron stains. It gives way to light grayish-brown calcareous more definitely stratified clay and sand that generally contains small shells and fragments of shells. Below a depth of 60 inches stratification is more pronounced and the material becomes more porous with depth. Gravel beds lie from 8 to 10 feet below the surface.

Most of this soil occurs in small basins and long narrow areas in the sand-dune district east of Blackfoot; the rest is on the Sterling terrace in scattered poorly drained salt-affected depressions. In the latter situation this soil has a lower subsoil layer and substratum of dense blocky clay, highly discolored and mottled from poor drainage. Most of these areas are pasture land, the grass cover is largely saltgrass, and none of the land is farmed. About 1 square mile of this soil east of Blackfoot also is poorly drained and charged with salts. It also is used only for pasture. With the exception of these areas, the soil is farmed.

The land is nearly flat to gently sloping. Surface run-off is slow or restricted, and on some areas surface water stands at all times. Internal drainage is slow. The fluctuating water table is highest during or following the irrigation season. Where the water table is sufficiently low, the soil is cultivated and is important in the sand-dune district, as in many places it constitutes the only tillable land available. Along the Blackfoot River it is used principally for native hay; the rest of the arable land is used mainly in the production of alfalfa, small grains, potatoes, and sugar beets. Alfalfa yields 2 to 4 tons an acre, wheat 25 to 55 bushels, barley 30 to 65 bushels, oats 30 to 65 bushels, potatoes 175 to 250 bushels, sugar beets 10 to 15 tons, and peas 15 to 35 bushels. The native hay yields from 1 to 1½ tons an acre. It consists of water-tolerant grasses and some rushes and reeds. Areas where the concentration of salt is high are used only for pasture and have a low carrying capacity for livestock.

The water requirement on farmed areas is low, varying with the saturation of the subsoil. This is often seasonal, as subirrigation plays an important part. Drainage is hardly feasible because of the occurrence of the soil in small basins associated with drifting dunelike sands. Crop rotation and management on this soil are similar to those practices on typical Blackfoot sandy loam.

Blackfoot loamy sand.—Blackfoot loamy sand, an inextensive soil, occurs southeast of Blackfoot. It lies adjacent to very sandy and dunelike soils and is noticeably modified by sandy materials blown from these areas. The surface soil ranges from the grayish-brown color of the Blackfoot soil to the medium brown pepper-and-salt color of the adjoining soils. There is likewise some variation in texture ranging from loamy fine sand to sand. The subsoil is more porous and stratified and considerably more gravel is present in places than in Blackfoot sandy loam. The loamy sand does not hold moisture so well as that soil, but it warms more readily in the spring. Underdrainage is favorable.

For the most part, the land is smooth and level to gently sloping, but some hummocky areas are included. The more uneven areas, representing about one-third of the total area, are not farmed. In this soil shorter runs and larger heads of water have to be employed for effective irrigation.

Most crops of the area are grown on this soil, but alfalfa and potatoes are most successful. Alfalfa yields 2½ to 4 tons an acre, potatoes 225 to 300 bushels, wheat 20 to 50 bushels, barley 25 to 55 bushels, and oats 25 to 55 bushels.

This soil is more deficient in organic matter and nitrogen than the other Blackfoot soils. Crop rotations that include alfalfa and other legumes, and the use of barnyard and green manures, are essential.

Onyx silt loam.—Onyx silt loam has a grayish-brown friable granular noncalcareous silt loam surface soil, about 15 inches thick, which, under irrigation, becomes calcareous. In most places it contains scattered gravel. It is underlain to a depth of about 40 inches by somewhat lighter grayish brown material that is slightly heavier textured but breaks into a granular or rather soft cloddy condition. It contains scattered gravel and is mildly calcareous, the lime being disseminated. Below this a stratified layer of yellowish-brown or grayish-brown silty clay loam extends to a depth of about 80 inches.

This material is calcareous and friable and is sprinkled with gravel. The underlying materials become increasingly gravelly and porous with depth.

The land is smooth and flat to gently sloping. Surface drainage is sufficient for effective run-off of excess water. Internal drainage is good, the water table stands at considerable depth, and the soil is very retentive of moisture. The lay of the land is favorable for effective distribution of irrigation water.

This is a very productive soil for all crops, but alfalfa, small grains, and potatoes are the principal crops grown. Alfalfa yields 2½ to 4½ tons an acre, wheat 35 to 70 bushels, barley 35 to 80 bushels, oats 35 to 90 bushels, and potatoes 250 to 400 bushels.

This soil is moderately high in organic matter, so that a regular crop rotation including alfalfa or other legumes will maintain the organic matter and nitrogen at a fairly high level. The additional use of barnyard manure, however, gives marked increases in yields. Because of the lime that is accumulating in the soil through irrigation, the use of phosphate for alfalfa undoubtedly would be justified.

The surface soil appears much darker when moist, as after irrigation and in the early spring. A few lower lying flat or basinlike areas have darker soils. Smaller included areas have a smooth fine-textured loam surface soil that is rather sticky and plastic when wet.

Most of this soil occurs immediately south of Fort Hall, but one small area lies southwest of Ferry Butte bordering the Snake River flood plain. The total area is small, but all the land is farmed.

Gooch silty clay.—To a depth of 10 or 12 inches Gooch silty clay is dark brownish-gray calcareous granular silty clay loam or silty clay. It is full of roots, and in many places the topmost few inches are peaty or covered with gray organic slime. In the natural moist condition the surface soil appears very dark grayish brown or almost black, but the dry surface soil appears definitely gray. It is underlain to a depth of about 50 inches by somewhat bluish-gray, slate-gray, or light-gray silty clay loam or silty clay of mealy structure mottled with iron stains. This layer is filled with fibrous roots. It rests on lighter slate gray or almost white marly silty clay containing platy accumulations of lime and in many places dark organic lenses or strata. Below a depth of 72 inches these materials are stratified with sandy materials, which overlie a substratum of water-worn gravel and sand.

This soil occurs mainly in back-bottom positions along the Snake River and within the Fort Hall Indian Reservation. The soil is wet, in many places marshy, as the areas are traversed by sluggish meandering streams having their origin in springs that issue from the substratum and from seepage from the higher lying terraces. Water-loving grasses, reeds, and rushes grow luxuriantly and form a matted sod. They supply a large quantity of native hay and pasture. In the lower depressions, many of which are peaty or mucky, and along streamways coarse rushes and cattails are the principal vegetation. Such areas produce very little hay because of the coarse vegetation and general inaccessibility of the land. No accumulations of salts have developed, probably because of leaching by the freely moving water.

This soil, which covers an area of 5.7 square miles, produces a large part of the native hay cut by the Indians for winter feeding of their livestock. It also affords extensive pasture during the open season. In the fall, when the water table becomes lower, haying operations begin. Hay yields from ½ to 1½ tons an acre.

Gooch silty clay loam.—Gooch silty clay loam covers a very small total area. It is closely associated with Gooch silty clay, where it occupies positions that are less saturated and marshy. The surface soil is similar in color to that of Gooch silty clay, but the texture is silty clay loam. The material in this layer generally has a lower organic-matter content and in many places lacks the dense sod and matted roots characteristic of that soil. The subsoil is essentially the same, but it does not have the dark organic layers that are present in places in the silty clay. Yields of hay are less than on the silty clay, but the hay generally is of better quality because the vegetation is not so rank and does not include the coarser rushes that grow on the wetter soil. All the land is used for native hay and pasture. Hay yields from ½ to 1 ton an acre.

Snake silty clay loam.—To a depth of about 14 or 16 inches the surface soil of Snake silty clay loam is dark dull grayish-brown or brownish-gray calcareous granular silty clay loam containing a considerable quantity of matted roots. This material is underlain to a depth of about 48 inches by light-gray highly calcareous silty clay that has a mealy and crumbly structure. Below this the silty clay materials are very light gray but are stained and mottled with blue, gray, and rust brown. At a depth of 76 inches the material is somewhat stratified with sand, which overlies gravelly and sandy material 7 to 10 feet below the surface.

This soil occurs within the Fort Hall Indian Reservation on the bottoms along the Snake River. It occupies back-bottom positions in close association with the Gooch soils. It is not cultivated but provides pasturage and occasionally a very small quantity of native hay.

The land is smooth and level to slightly undulating. As it occupies higher positions than the Gooch soils, this soil is not marshy. Although the water table rises almost to the surface in spring, it subsides to the lower part of the subsoil in fall. Accumulations of salt occur but are not conspicuous.

The native-grass vegetation is not luxuriant enough to justify cutting for hay, but it supplies a good quality of pasture. Scattered joint grass (or knotgrass), plantain, and flowering annuals make up a part of the vegetation.

Snake silty clay.—Snake silty clay, to a depth of about 14 inches, is dull grayish-brown or brownish-gray calcareous granular or crumbly silty clay. Matted roots of the grass vegetation are prominent. This layer is underlain to a depth of about 50 inches by lighter brownish gray more highly calcareous mealy or crumbly silty clay that is soft and friable. Below this the material is light brownish-gray or grayish-white silty clay mottled with bluish gray and rust brown. This material is somewhat marly. At a depth of 70 inches the underlying materials are stratified with lighter sandy and gravelly materials discolored by poor drainage.

Areas of this soil are scattered over the bottom lands of streams within the Fort Hall Indian Reservation east of Snake River, and

some lie outside the reservation north of Ferry Butte. The total area is about 2½ square miles, only a small part of which is cultivated.

The land is smooth and nearly level but includes some slightly undulating variations. It occupies positions slightly above the Gooch soils; consequently it is better drained and not marshy. It lies lower, however, than the other Snake soils, and the water table stands nearer the surface. The soil is not wet enough to support so luxuriant a vegetation as that on the Gooch soils; it produces little native hay but considerable pasturage of good quality. The vegetation is similar to that on Snake silty clay loam. Accumulations of salt are not sufficient to promote the growth of saltgrass, but slight accumulations are discernible in places on the surface.

Snake fine sandy loam.—Only a very small total area of Snake fine sandy loam is mapped. It occurs as small scattered areas associated with the other Snake and Gooch soils on rounded elevations or swells. In places the sandy surface soil has the appearance of having been blown over the underlying heavier textured materials of the Gooch and Snake soils, but there are also variations in which the sandy texture predominates down to the underlying gravelly substratum. The surface soil generally is light medium-brown or light grayish-brown friable fine sandy loam to a depth of about 12 or 14 inches. The subsoil is variable as indicated but is generally browner than the corresponding layer of other soils of the Snake series.

The water table stands lower in this soil than in the other soils on the bottoms; consequently the soil supports only a sparse grass vegetation, which is not sufficiently dense to be cut for hay and is only pastured. Accumulations of salts are about the same as in Snake silty clay loam.

Logan silty clay loam.—To a depth of about 5 inches the surface soil of Logan silty clay loam is calcareous granular silty clay loam matted by fibrous roots, forming a dense sod. This highly organic material is dark grayish brown to almost black, the darker color appearing under the more moist conditions. In some of the deeper depressions the surface is covered with a peaty layer or a slimy organic scum, the latter gives the soil a grayer appearance. The surface soil is underlain to a depth of about 20 inches by very dark grayish-brown silty clay that has a very granular structure and contains fewer roots. This material is abruptly underlain by light brownish-gray or grayish-white plastic puttylike silty clay with some organic staining. Below a depth of 50 inches is light-gray or grayish-white silty clay with green and rust-brown stains. The underlying materials below a depth of 6 feet range from gravel along the Blackfoot River to tough blocky lake clay on the Sterling terrace. In many places on this terrace the surface soil is not so thick or so highly organic as in the Blackfoot River bottoms.

The total area of this soil is not large. All but about 100 acres that lie adjacent to the Blackfoot River east of Blackfoot occurs on the Sterling terrace. The better drained area near the Blackfoot River produces native hay, but the rest of the land is used only for pasture.

For the most part, this soil occupies low areas in flat bottom lands and depressions or along sluggish streams. Most of it is flooded the

greater part of the year and supports a rank vegetation of cattails, tules, and rushes. Some areas support saltgrass. All areas except the one by the Blackfoot River are highly charged with salts and afford only a coarse type of pasturage.

Logan sandy loam.—Small scattered bodies of Logan sandy loam, aggregating a very small total area, lie north of Sterling. This soil is submerged throughout the year and lacks well-developed layers. It consists of sandy materials that apparently have been blown in and deposited over the massive clay substratum. The sandy surface material is variable in depth, but the clay subsoil generally lies within 2 to 4 feet of the surface. The surface soil is not so dark, so highly organic, or so thick as that of Logan silty clay loam. The subsoil is light gray highly mottled and stained by rust brown, green, and blue.

Cattails, tules, rushes, and some saltgrass in scattered areas make up the principal vegetation. The pastures have a low carrying capacity.

MISCELLANEOUS LAND TYPES

In addition to the recognized soil types and phases, certain areas have been classified as miscellaneous land types. This land is mainly nonagricultural, has no consistent soil characteristics, and some of the soils are shallow or stony.

Scabland.—Scabland consists of a complex pattern of small pockets or areas of shallow sagebrush-covered soil and barren basalt outcrop so intermixed that their separate delineation on the soil map is not practicable. A continuous area of barren lava beds, practically devoid of soil cover and vegetation and extending northward from the vicinity of the Lava Side School, is included. Scabland extends almost continuously along the entire western edge of the area and in a large degree defines the limits of agricultural development. It occupies about one-seventh of the area.

Because of the unevenness of the lava beds that underlie the entire Blackfoot-Aberdeen area, outcrops of bedrock are common. Outcrops are especially prominent where these beds rise naturally above the surrounding soils or where they have been exposed by erosion. Small areas of scabland not large enough to be mapped are indicated by rock-outcrop symbols. Where there is sufficient soil cover these may be identified with almost any series of soils, depending on the soil with which they are associated—generally the Portneuf, Sagemoor, Declo, Fingal, and Bannock. The soil areas in the scabland are not of sufficient size to justify cultivation, but a few of them are irrigated for pasture. Scattered bunchgrasses furnish very limited native pasture. Small areas that have become affected by seepage from irrigation and by accumulations of salts afford considerable saltgrass pasture.

Stony land.—Stony land consists of land so stony that it is almost entirely unsuited to cultivation. It ranges from undulating to rolling or knobby and resembles scabland, but the stones consist largely of huge transported boulders rather than of outcropping bedrock, such as that in scabland. The boulders either are embedded in lake-laid clays or rest on the surface over the clays. The uneven relief probably is due largely to erosion, as the clays have been removed where not protected by the massed boulders. Most of the areas lie near the shore line of

the prehistoric lake, and the boulders probably were brought in by floating ice.

Large and small bodies of stony land are widely distributed from a point north of Aberdeen to the vicinity of Moreland. Most of these areas are in the vicinity of Pingree. The aggregate area is about 13 square miles. Very little of this land is farmed, as it is infeasible to remove the massive boulders. Scattered bunchgrasses, growing in association with the sagebrush, provide some pasturage. Waste water from irrigation is sometimes used to improve the pastures.

The soil materials in these stony areas are mainly identified with soils of the Sagemoor and the Fingal series, which they adjoin.

Riverwash.—Riverwash consists of extensive flood-plain deposits of gravel, stone, and sand that are unfit for agricultural development. They occur along the Snake River from the vicinity of Shelley to the American Falls Reservoir and comprise a total area of 11.5 square miles.

All these areas lie within the immediate flood plain of the river and are traversed by the main channel and the many meandering side channels and sloughs, some of which carry water only during high water. These drainageways frequently change their course, reworking and redepositing the unstable materials. The more stable interstream areas support brush and some grass, which furnish limited pasturage and browse for livestock. Along the channels and in areas of sufficient moisture there are groves of cottonwood and a dense growth of willow.

Rough broken land.—Rough broken land, as it occurs in this area, consists mainly of long narrow strips of steep broken land or bluffs along the edges of terraces. These are widely distributed but have a relatively small aggregate area. They are nonagricultural and afford very little pasture.

The surface soil is extremely variable in thickness and texture from place to place, and much of it, representing materials of contiguous areas of the Sagemoor, Fingal, and Bannock soils, has been removed by sheet erosion, which has exposed the more compact resistant lime layer. This layer and the underlying gravelly substratum have, in turn, been cut by gullies that penetrate back into the terrace. The substratum generally is exposed in vertical walls because of the protecting lime layer.

Some of the areas consist mainly of the broken terrace front facing the American Falls Reservoir. Here clay strata are exposed along the bluff, which rises vertically about 20 feet above the reservoir. Seepage water and springs issue from these clay materials.

Rough broken land (Wheeler soil material).—Rough broken land that is identified with the Wheeler soil material occupies 8.3 square miles of the high bench east and south of Goshen. None of it is farmed or otherwise used for agriculture, owing to the steep, rough, broken relief. Deep steep-sided draws and gullies are numerous along the larger intermittent stream channels, and smaller streamways invade the uplands so that only small scattered smooth areas and rounded ridges remain. Outcrops of the underlying bedrocks are numerous and old gravel strata are exposed here and there. Development of a soil profile is irregular, and the soil materials are highly calcareous. Almost white exposures of limy layers are common. Only a limited amount of grazing is afforded.

PRODUCTIVITY RATINGS AND PHYSICAL LAND CLASSIFICATION

In table 5 the soil series of the Blackfoot-Aberdeen area are listed alphabetically and the estimated range in acre yields of the principal crops is given for each soil under irrigation and the prevailing practices of soil management. Under natural conditions these soils have limited agricultural value, but under irrigation many of them are highly productive.

The estimates in table 5 are based primarily on interviews with farmers, the county agricultural agent, members of the State experiment station staff, members of the college of agriculture staff, and others who have had experience in the agriculture of this area. They are presented simply as estimates of the range in production over a period of years according to the prevailing type of management. It is realized that these estimates may not apply directly to specific tracts of land, inasmuch as the soils shown on the map vary somewhat. Some of the soils vary considerably in drainage and in accumulation of salts, and yield estimates given are for the better drained areas and the less salty areas. Some of the soils are not irrigated now, but possibly they may be later. Their potential productivity is estimated on the basis of their physical and chemical properties in comparison with the soils that are under irrigation.

In order to compare directly the yields obtained in the Blackfoot-Aberdeen area with those obtained in other parts of the country, yield figures have been converted in table 6 to indexes based on standard yields. The soils are listed in the approximate order of their general productivity and suitability for irrigation under the common practices, beginning with the most productive.

The crop productivity index or rating compares the productivity, under irrigation, of each of the soils (soil types, phases, and land types) for each crop with a standard of 100. This standard index represents the approximate average acre yield obtained without the use of amendments on the more extensive and better soil types of the regions of the United States in which the crop is most widely grown. An index of 50 indicates that the soil is about half as productive for the specified crop as is the soil with the standard index. The standard yield for each crop shown in table 6 is given at the head of each of the respective columns. It is to be noted that the standards given here for alfalfa seed and clover seed have been used so far only in this area. They are not to be accepted as standards for these crops for all sections of the country. Soils given amendments, such as commercial fertilizers, or special practices, such as irrigation, and unusually productive soils of small extent may have productivity indexes of more than 100 for some crops. A considerable number of the indexes for the Blackfoot-Aberdeen area are above 100, since production here is under irrigation.

The principal factors affecting the productivity of land are climate, soil (including the many physical, chemical, and biological characteristics), slope, drainage, and management (including the use of amendments). No one of these factors operates separately from the others, although some one may dominate. In fact, the factors listed may be grouped simply as the soil factor and the management factor, since slope, drainage, and most of the aspects of climate

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TABLE 5.—*Estimated average acre yields of the important crops on each soil in the Blackfoot-Aberdeen area, Idaho, under the common practices of irrigation farming* [1]

Soil (soil types, phases, and land types)	Alfalfa	Potatoes	Sugar beets	Wheat	Oats	Barley	Peas	Alfalfa seed	Clover seed	Beans	Native hay	Remarks as to principal use and crops
	Tons	*Bushels*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Tons*	
Ammon very fine sandy loam	4 -5	250-400	10-18	35-75	60-120	60-90	15-45	-------	3-15	-------	-------	Used principally for alfalfa, sugar beets, potatoes, and wheat.
Ammon silt loam	4 -5	250-400	10-18	35-75	60-120	60-90	15-45	-------	3-12	-------	-------	Do.
Ammon silt loam, slope phase	3 -4	175-300	7-15	25-60	40- 90	40-70	10-35	-------	2-10	-------	-------	Do.
Bannock fine sand	2.5-4	100-250	3- 7	5-20	7- 20	5-15	2-10	3- 8	-------	-------	-------	Three-fourths in alfalfa.
Bannock fine sand, hummocky phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	Not cropped.
Bannock loamy fine sand	3 -4.5	225-330	8-12	15-30	30- 70	25-60	8-20	3-10	-------	-------	-------	Nearly all in crops. Soil-blowing is a hazard.
Bannock sandy loam	3.5-5.5	225-400	10-15	20-50	25- 60	20-55	10-25	3-12	-------	10-30	-------	Nearly all in crops.
Bannock sandy loam, slope phase	2.5-3.5	150-275	7-10	15-35	15- 40	12-35	7-15	2- 8	-------	7-20	-------	All in crops.
Bannock fine sandy loam	3.5-5.5	225-400	10-15	20-60	30- 70	30-65	10-35	5-15	5-10	15-40	-------	Less than one-half in crops.
Bannock gravelly fine sandy loam	2.5-4.5	150-300	7-12	15-45	20- 55	20-50	7-30	3-12	-------	10-30	-------	
Bannock gravelly fine sandy loam, shallow phase.	1.5-3	125-250	4- 9	4-12	10- 35	8-25	3-10	-------	-------	-------	-------	
Bannock gravelly fine sandy loam, slope phase.	2 -3.5	125-250	5-15	7-18	15- 45	15-35	5-15	-------	-------	-------	-------	
Bannock very fine sandy loam	3 -4.5	225-400	7-14	30-75	55-105	55-85	15-35	-------	4-12	15-35	-------	
Bannock very fine sandy loam, slope phase	2.5-4	150-300	6-12	15-50	35- 75	30-60	10-25	-------	2- 8	10-25	-------	One-half in crops.
Bannock loam	3 -5	250-400	8-16	30-75	55-100	50-90	15-40	-------	4-10	15-40	-------	All in crops.
Bannock gravelly loam	2 -4	175-300	6-12	20-60	40- 75	35-70	12-30	-------	3- 8	12-30	-------	
Bannock gravelly loam, shallow phase	1.5-3	100-200	4- 9	5-12	15- 40	10-30	4-12	-------	-------	-------	-------	
Bannock gravelly loam, slope phase	1.5-3	125-225	5-15	7-20	15- 50	15-35	7-18	-------	-------	-------	-------	
Bannock silt loam	3 -4.5	225-400	7-14	30-75	55-105	55-85	15-35	-------	4-12	15-35	-------	All in crops.
Bannock silty clay loam	3 -4.5	225-350	8-15	35-80	50-100	55-90	15-45	8-16	5-12	15-35	-------	One-half of area in alfalfa; all in crops.
Bannock gravelly silty clay loam	2 -3.5	150-275	7-12	20-60	40- 90	35-75	10-35	6-12	3- 9	12-25	-------	
Beverly fine sand	1.5-4	75-175	2- 6	2-10	5- 20	5-15	2-10	-------	-------	-------	-------	None in crops.
Beverly fine sand, eroded phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	Do.
Beverly gravelly fine sand	1 -3	75-150	3- 6	5-30	10- 35	12-30	5-12	-------	-------	-------	-------	
Beverly very fine sandy loam	2.5-4	125-250	6-12	20-55	20- 65	25-60	10-25	-------	-------	-------	-------	Most of the area used for crops.
Beverly very fine sandy loam, gravelly phase.	1.5-3	75-175	4- 9	12-35	12- 40	15-40	7-18	-------	-------	-------	-------	Do.
Beverly loam	2.5-4	175-250	8-12	30-60	30- 70	30-65	15-30	-------	-------	10-25	-------	One-third to one-half in alfalfa; one-fourth in wheat and other small grains.
Beverly silty clay loam	3 -4.5	175-250	8-14	35-65	30- 75	30-70	15-35	-------	-------	-------	-------	All in crops.
Blackfoot loamy sand	2.5-4	225-300	8-15	20-50	25- 55	25-55	10-25	-------	-------	-------	-------	
Blackfoot sandy loam	3 -4.5	225-300	12-20	30-65	30- 75	30-70	20-40	-------	-------	-------	-------	All in crops.
Blackfoot sandy loam, poorly drained phase.[2]	2 -4	175-250	10-15	25-55	30- 65	30-65	15-35	-------	-------	-------	1-1.5	Some in crops.
Blackfoot fine sandy loam	3 -4.5	220-300	12-20	30-65	30- 75	30-70	20-40	-------	-------	-------	-------	All in crops.
Blackfoot fine sandy loam, broken phase	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	None in crops.
Blackfoot loam	2.5-4	175-225	12-20	35-70	40-100	35-80	25-50	-------	-------	-------	-------	All in crops.
Blackfoot loam, poorly drained phase [2]	2.5-4	175-200	12-20	35-70	40-100	35-80	25-50	-------	-------	-------	1-1.5	Pasture; some in crops.
Blackfoot silty clay loam	2 -3	125-225	10-18	35-70	40-100	35-80	25-50	-------	-------	-------	-------	All in crops.

Blackfoot silty clay loam, poorly drained phase.[2]	2.5-3.5	125-250	10-18	35-70	40-100	35-80	25-50				1-1.5	About one-half in crops.
Declo loamy fine sand	3 -4.5	220-350	8-12	20-55	25- 60	25-60	10-25	5-14				Most of it is in crops. Needs nitrogen and organic matter.
Declo loamy fine sand, slope phase	2 -3	150-300	6-12	10-45	20- 50	20-50	7-18	4-12				Do.
Declo sandy loam	3.5-5.5	250-450	10-15	25-65	35- 75	30-70	15-25	5-14	5-12			Nearly all in crops. Manure and crop residues needed.
Declo sandy loam, slope phase	3 -4.5	175-325	8-12	20-45	25- 60	25-60	10-25	5-14				About three-fourths in crops.
Declo fine sandy loam	3.5-5.5	250-450	10-15	25-65	35- 75	30-70	15-35	5-14	5-12			All in crops.
Declo very fine sandy loam	4 -5	250-400	10-18	35-75	50-100	55-85	15-40	5-12	5-12	10-30		
Declo very fine sandy loam, slope phase	2.5-4	175-325	6-12	25-60	35- 70	35-75	15-25	5-12	3- 8			
Declo loam	4 -5	250-400	10-18	35-75	50-100	55-85	15-40	5-12	5-12	10-30		All in crops.
Declo loam, slope phase	3 -4	200-325	6-12	25-60	35- 70	35-70	15-25	5-12				
Declo loam, steep phase												None in crops.
Declo silt loam	4 -5	250-400	10-18	35-75	50-100	55-85	15-40	5-12	5-12	10-30		
Declo silt loam, slope phase	2.5-4	175-325	6-14	25-60	35- 70	30-70	15-35	5-12				Nearly all in crops.
Declo silty clay loam	3.5-5	220-350	8-18	35-85	60-120	60-95	15-45		4-10	7-25		All in crops.
Declo silty clay loam, slope phase	2.5-4	175-325	7-15	25-60	35- 70	30-70	15-35	5-12				
Fingal sand	2 -4	100-200	3- 9	3-10	10- 20	8-15	2-10					
Fingal sand, hummocky phase												In pasture.
Fingal loamy sand[2]	2 -5	125-300	7-12	15-30	15- 40	10-40	5-15	3-10				
Fingal sandy loam[2]	2 -5	125-225	7-12	10-20	15- 40	15-40	7-18	3- 8				One-third or less in crops. Pasture on salty areas.
Fingal fine sandy loam[2]	2 -5	125-225	7-12	10-20	15- 40	15-40	7-18					Small area in crops.
Fingal fine sandy loam, slope phase[2]	2 -5	125-225	5-10	7-18	15- 40	15-35	5-15					
Fingal loam[2]	1.5-3	125-250	8-12	20-55	30- 65	30-60	15-30					Less than one-half in crops. Pasture on salty areas.
Fingal loam, slope phase[2]	1.5-3	100-200	7-12	10-25	15- 45	15-40	8-20					
Fingal silty clay loam												None in crops.
Gooch silty clay loam											.5-1	
Gooch silty clay											.5-1.5	
Logan sandy loam												Poor pasture.
Logan silty clay loam											.5-1	Pasture—some hay.
Onyx silt loam	2.5-4.5	250-400	10-18	35-70	35- 90	35-80	25-50					
Paul sand	2 -4	150-300	5-10	10-30	15- 40	10-50	7-20					Alfalfa and potatoes most important crops.
Paul loam	3 -5	225-400	12-16	30-75	55- 95	55-95	15-35					
Paul silty clay loam	2.5-4.5	225-300	10-16	40-80	60-110	60-95	15-40					All in crops.
Paul silty clay	2.5-4	175-250	10-15	40-80	60-110	60-90	15-40					Do.
Portneuf loamy fine sand	4 -5	175-360	8-16	25-40	35- 70	25-60	10-25	3-12				One-half in crops.
Portneuf loamy fine sand, rolling phase	2 -4	100-250	7-12	15-30	15- 40	15-35	5-15	2-10				Less than one-half in crops.
Portneuf very fine sandy loam	4 -5.5	250-400	10-20	25-50	40- 80	35-75	15-35					
Portneuf very fine sandy loam, rolling phase	2 -3	100-200	7-12	10-25	15- 40	15-35	8 20					One-half in crops.

[1] Common practices of irrigation farming include a rotation of alfalfa for 3 or 4 years, followed by sugar beets or potatoes and wheat for 2 years. Phosphate is commonly applied for sugar beets and to a lesser degree for alfalfa. Barnyard manure where available is applied for small grains, potatoes, and sugar beets.

[2] Yields given for these soils apply only to the better drained areas that are relatively free from an accumulation of salts.

TABLE 5.—*Estimated average acre yields of the important crops on each soil in the Blackfoot-Aberdeen area, Idaho, under the common practices of irrigation farming*—Continued

Soil (soil types, phases, and land types)	Alfalfa	Potatoes	Sugar beets	Wheat	Oats	Barley	Peas	Alfalfa seed	Clover seed	Beans	Native hay	Remarks as to principal use and crops
	Tons	*Bushels*	*Tons*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Tons*	
Portneuf silt loam	4 5	250–400	10–18	35–75	60–120	60–90	15–45		3–12			Alfalfa, sugar beets, potatoes, wheat.
Portneuf silt loam, rolling phase	2 -3.5	175–250	8–12	25–50	40– 70	35–60	15–35					Do.
Portneuf silt loam, steep phase												Not cropped.
Riverwash												
Rough broken land												
Rough broken land (Wheeler soil material)												Limited grazing.
Rupert fine sand	1.5–3	50–150	2– 6	2–10	4– 15	3–10		3–12				Three-fourths in crops.
Rupert fine sand, dune phase												None in crops.
Rupert fine sand, rolling phase												Very little cropped.
Rupert gravelly loamy sand	1.5–3	50–150	2– 6					3–12				Do.
Sagemoor fine sandy loam	4 -5	250–350	8–15	25–65	40– 80	35–75	15–35	8–18				Probably two-thirds of area in alfalfa hay and seed.
Sagemoor fine sandy loam, *shallow* phase	2 -3	100–200	4– 9	10–30	4– 15	10–30	3–10	3– 8				About one-half in crops.
Sagemoor fine sandy loam, slope phase	1.5–3	100–200	7–12	10–25	15– 40	15–35	8–20	6–15				Used largely for alfalfa seed.
Sagemoor fine sandy loam, steep phase								3– 8				Pasture and alfalfa hay and seed are the principal uses.
Sagemoor very fine sandy loam	3.5–5	250–350	8–15	30–70	50–100	50–80	15–45	6–15				Most of the soil is in crops.
Sagemoor very fine sandy loam, shallow phase.	2 -3	75–175	4– 9	10–35	15– 40	15–35	4–12	3– 7				About one-half of area in crops.
Sagemoor very fine sandy loam, slope phase.	2 -4.5	175–300	5–10	20–55	35– 70	30–70	15–25	6–15				Alfalfa seed very important.
Sagemoor silt loam	3 -5.5	220–325	8–15	35–80	60–120	60–90	15–40	6–15	3–12			
Sagemoor silt loam, shallow phase	2 -3	75–175	4– 9	10–35	15– 40	15–35	4–12	3– 7				Less than one-half farmed.
Sagemoor silt loam, slope phase	2 -4	125–250	5 10	25–60	35– 70	35–65	15–35	5–12				
Sagemoor silty clay loam	3 -5	220–325	8–19	40–85	60–120	65–95	20–45	4–10		10–30		More than one-half of area in alfalfa.
Sagemoor silty clay loam, slope phase	2 -5	150–300	7–15	25–75	40– 90	30–80	15–40					Rather similar crops and yields to the silty clay loam.
Scabland												
Snake fine sandy loam												Pasture.
Snake silty clay loam												Mostly pasture, some hay.
Snake silty clay											1– 5	Do.
Stony land												
Wheeler very fine sandy loam												Very little in crops; under irrigation yields approximate those on the Portneuf soils.
Wheeler very fine sandy loam, steep phase												Not in crops.
Wheeler silt loam												Very little in crops at present; under irrigation yields are similar to Portneuf.
Winchester sand												None in crops.
Winchester sand, dune phase												Do.

may be considered as characteristics of a given soil type and since the soil type, as such, occupies specific geographic areas characterized by a given range of slope and climatic conditions. Crop yields over a long period of years furnish the best available summation of the associated factors and therefore are used where available.

The soils are listed in table 6 in the order of their general productivity according to the prevailing practices of irrigation farming, except that in a few instances other considerations, such as the workability of the soil and the ease of distribution and efficiency of the use of water, have been taken into consideration together with productivity to group the soils in the five classes shown in the right-hand column of the table. For example, the indexes of Beverly very fine sandy loam, a soil included as a First-class soil, are less than those for Portneuf loamy fine sand, a soil grouped with the Second-class soils. In this instance Beverly very fine sandy loam, because of other characteristics than productivity alone, is considered to be more desirable for general irrigation farming than is Portneuf loamy fine sand. With the exception of these few instances that are evident from an inspection of table 6, the soils are listed in the order of their general productivity. General productivity grade numbers are assigned in the column "General productivity grade." The general productivity grade is based on a weighted average of the indexes for the various crops, the weighting depending on the relative acreage and value of the crops. If the weighted average is between 90 and 100, the soil type is given a grade of 1; if it is between 80 and 90, a grade of 2 is given, and so on.[8]

In the Blackfoot-Aberdeen area the average of these indexes on some of the soil types is as high as 140. In order to distinguish between those soils that have average indexes above 100, the letters a, b, c, d, and e have been added to the grade number, 1. Thus, soils with the productivity grade 1e have an average index of 140 to 150; those with 1d, 130 to 140; 1c, 120 to 130; 1b, 110 to 120; and 1a, 100 to 110. Since it is difficult to measure mathematically either the exact significance of a crop in the agriculture of an area or the importance or suitability of certain soils for particular crops, perhaps too much significance may be given to the order in which the soils are listed. On the other hand, the arrangement in table 6 does give information as to general productivity of the soils and as to their general desirability for use for irrigation farming. The column "General productivity group" is a broad grouping to bring out in general terms the relative productivity of the soils of the Blackfoot-Aberdeen area.

Productivity tables do not present the relative roles that soil types, because of their extent and the pattern of their distribution, play in the agriculture of the area. The tables show the relative productivity of individual soils. They cannot picture in a given county or area the total quantitative production of crops by soil areas without the additional knowledge of the acreage of the individual soil types devoted to each specified crop.

Economic considerations play no part in determining the crop productivity indexes. They cannot be interpreted, therefore, into land

[8] Instead of following the usual procedure for weighting the indexes of all the individual crops, the general productivity grade numbers in table 6 have been assigned from an average of the index ratings for alfalfa, potatoes, sugar beets, and wheat. The placing of the soils, therefore, results from an approximation of the average of the indexes for these four crops.

TABLE 6.—*Productivity ratings of the soils of the Blackfoot-Aberdeen area, Idaho, under irrigation*

Soil (soil types, phases, and land types) [1]	Crop productivity index [2] for—												General productivity		Grouping or classification of soils on basis of general suitability for irrigation agriculture
	Alfalfa (100=4 tons)	Potatoes (100=200 bu.)	Sugar beets (100=12 tons)	Wheat (100=25 bu.)	Oats (100=50 bu.)	Barley (100=40 bu.)	Peas (100=25 bu.)	Beans (100=25 bu.)	Alfalfa seed (100=10 bu. [3])	Clover seed (100=7 bu. [3])	Native hay (100=1 ton)	Native pasture (100=100 cow-acre-days [4])	Grade [5]	Group [6]	
Portneuf silt loam	110	165	120	180	130	165	100			85			1e	Very high productivity.[7]	First-class soils. (Well suited to irrigation because of high productivity, easy workability, ease of distribution and efficiency of use of water, etc.)
Ammon silt loam	110	165	120	180	160	165	100			85			1e		
Ammon very fine sandy loam	110	165	120	180	160	165	100			85			1e		
Wheeler silt loam [7]	110	165	120	180	160	165	100						1e		
Sagemoor silty clay loam	110	150	100	200	160	180	110	90	40				1e		
Declo very fine sandy loam	120	165	120	180	130	155	100	90	70	100			1e		
Declo loam	120	165	120	180	130	155	100	90	70	100			1e		
Declo silt loam	110	150	120	190	160	170	100	90	70	100			1e		
Declo silty clay loam	100	150	120	190	160	170	100	80		85			1e		
Portneuf very fine sandy loam	120	160	125	155	95	110	85						1e		
Sagemoor silt loom	95	150	100	190	160	165	100		90	85			1d		
Sagemoor very fine sandy loam	100	150	100	180	150	160	100		90				1d		
Declo fine sandy loam	120	160	110	130	95	105	85		80	100			1d		
Paul loam [8]	95	150	115	180	130	155	90						1d		
Bannock silt loam	90	140	95	170	150	155	90	100		100			1c		
Bannock very fine sandy loam	90	140	95	170	150	155	90	100		100			1c		
Bannock silty clay loam	90	130	100	190	150	155	95	100	100	100			1c		
Bannock loam	95	150	100	160	145	145	90	100		85			1c		
Paul silty clay loam	80	125	110	200	150	170	95						1c		
Blackfoot loam	80	100	120	180	120	115	125						1c		
Blackfoot fine sandy loam	90	125	120	165	90	100	100						1c		
Declo sandy loam	120	160	110	120	85	95	80		80	100			1c		
Paul silty clay	75	100	105	180	140	170	95						1b		
Blackfoot silty clay loam	60	80	115	180	120	115	125						1b		
Onyx silt loam	85	150	115	160	105	115	125						1b		
Blackfoot loam, poorly drained phase [8]	80	95	120	180	120	115	125				125		1b		
Blackfoot silty clay loam, poorly drained phase [8]	70	90	115	180	120	115	120				125		1b		
Sagemoor fine sandy loam	110	130	100	135	95	110	85		100				1b		
Bannock fine sandy loam	100	150	105	110	80	85	75	100	80				1b		
Bannock sandy loam	100	150	105	100	70	75	70	90	60				1b		
Blackfoot sandy loam	85	125	110	135	75	90	95						1b		
Beverly silty clay loam	90	100	90	140	80	85	85						1a		
Blackfoot sandy loam, poorly drained phase.[8]	75	105	105	120	65	95	85				125		1a		
Beverly loam	65	105	80	140	80	90	75	70					1		
Beverly very fine sandy loam	75	105	75	110	70	75	70						1		

Portneuf loamy fine sand	110	130	100	105	85	80	70		60				1b	High to very high productivity.	Second-class soils. (Moderately well suited to irrigation. These soils are less desirable than First-class soils because of lower productivity; greater difficulty of cultivation, irrigation, or erosion control; or less efficient use of water. Undesirable soil characteristics are sloping or uneven topography, high content of sand or gravel, and, in one instance, imperfect drainage.)
Portneuf silt loam, rolling phase	70	105	90	110	85	100	85						1		
Ammon silt loam, slope phase	70	105	90	110	85	110	85			70			1		
Wheeler very fine sandy loam [7]	70	105	90	110	85	100	85					10	1		
Declo loam, slope phase	75	110	75	115	85	110	80		70				1		
Declo very fine sandy loam, slope phase	75	95	75	115	85	110	80		70	70			1		
Declo sandy loam, slope phase	90	100	85	95	80	85	70		80				1		
Bannock loamy fine sand	95	130	80	80	80	80	60		50				1		
Declo loamy fine sand	85	130	85	90	70	80	70		80				1		
Blackfoot loamy sand	75	125	85	90	65	80	75						1		
Bannock very fine sandy loam, slope phase.	70	100	85	115	80	95	75	85		60			1		
Sagemoor silt loam, slope phase	65	90	65	115	90	105	85		70				2		
Sagemoor very fine sandy loam, slope phase.	70	95	65	110	85	95	80		90				2		
Sagemoor silty clay loam, slope phase	65	85	65	115	90	105	85						2		
Declo silty clay loam, slope phase	65	90	65	115	85	105	85		70				2		
Declo silt loam, slope phase	70	95	70	115	85	105	85		70				2		
Bannock gravelly loam	70	100	65	90	95	95	60	90		70			2		
Fingal loam [8]	60	85	85	110	80	90	75						2		
Bannock gravelly silty clay loam	65	90	65	90	95	100	60	85	80	70			3		
Bannock gravelly fine sandy loam	70	105	65	75	55	55	55	90	60				3		
Beverly very fine sandy loam, gravelly phase.	60	80	50	85	45	50	45						4		
Fingal sandy loam [8]	65	85	80	60	50	60	50		50				3	Medium productivity.	Third-class soils. (Fairly well to poorly suited to irrigation. Sloping or rolling topography, droughtiness, or poor drainage are characteristics that lower the suitability of these soils for irrigation farming.)
Fingal fine sandy loam [8]	65	85	80	60	50	60	50						3		
Declo loamy fine sand, slope phase	65	90	75	60	45	55	50		70				3		
Fingal loamy sand [8]	85	85	70	50	40	40	40		50				3		
Bannock sandy loam, slope phase	70	100	75	55	40	45	55	60	40				3		
Portneuf loamy fine sand, rolling phase	70	85	65	60	45	50	40		50				3		
Portneuf very fine sandy loam, rolling phase.	65	80	65	60	40	45	60						4		
Sagemoor fine sandy loam, slope phase	55	70	65	70	50	55	60		90				4		
Fingal loam, slope phase [8]	55	70	65	65	55	60	60						4		
Paul sand	70	100	60	45	40	40	50						4		
Bannock gravelly loam, slope phase	60	80	60	50	60	60	45						4		
Bannock gravelly fine sandy loam, slope phase.	65	85	60	45	55	55	40						4		
Fingal fine sandy loam, slope phase [8]	60	75	55	45	50	55	40						5	Medium to low productivity.	
Sagemoor silt loam, shallow phase	60	60	50	60	40	45	30		40				5		
Sagemoor very fine sandy loam, shallow phase.	60	60	50	60	40	45	30		40				5		
Sagemoor fine sandy loam, shallow phase.	60	70	50	55	35	40	25		50				5		
Bannock gravelly loam, shallow phase	55	70	50	35	40	40	30						5		
Bannock gravelly fine sandy loam, shallow phase.	60	75	50	30	35	35	25						5		
Fingal sand	70	70	45	25	30	30	20						5		
Beverly gravelly fine sand	55	60	40	30	35	35	25						6		
Bannock fine sand	65	65	40	25	25	25	20		50				6		
Beverly fine sand	60	60	35	20	20	20	15						6		
Rupert fine sand	55	55	25	20	15	15			60				7		
Rupert gravelly loamy sand	55	55	25	10	10	10			60				7		

TABLE 6.—*Productivity ratings of the soils of the Blackfoot-Aberdeen area, Idaho, under irrigation*—Continued

Soil (soil types, phases, and land types) [1]	Crop productivity index [2] for—												General productivity		Grouping or classification of soils on basis of general suitability for irrigation agriculture
	Alfalfa (100=4 tons)	Potatoes (100=200 bu.)	Sugar beets (100=12 tons)	Wheat (100=25 bu.)	Oats (100=50 bu.)	Barley (100=40 bu.)	Peas (100=25 bu.)	Beans (100=25 bu.)	Alfalfa seed (100=10 bu. [3])	Clover seed (100=7 bu. [3])	Native hay (100=1 ton)	Native pasture (100=100 cow-acre-days [4])	Grade [5]	Group [6]	
Gooch silty clay											100	90	7	Low productivity.	Fourth-class soils. (Naturally poorly drained soils, commonly used for pasture or wild hay.)
Gooch silty clay loam											75	65	8		
Logan silty clay loam											75	60	8		
Snake silty clay											30	30	9		
Logan sandy loam												40	9		
Snake silty clay loam												25	10		
Fingal silty clay loam												25	10		
Snake fine sandy loam												20	10		
Sagemoor fine sandy loam, steep phase [9]	20								50			10	9	Very low productivity.	Fifth-class soils. (Generally unsuited for irrigation farming, and used principally as range land.)
Blackfoot fine sandy loam, broken phase												20	10		
Beverly fine sand, eroded phase												15	10		
Rupert fine sand, rolling phase												15	10		
Rupert fine sand, dune phase												15	10		
Winchester sand												15	10		
Winchester sand, dune phase												15	10		
Bannock fine sand, hummocky phase												15	10		
Fingal sand, hummocky phase												15	10		
Portneuf silt loam, steep phase												10	10		
Wheeler very fine sandy loam, steep phase												10	10		
Rough broken land (Wheeler soil material)												10	10		
Rough broken land												10	10		
Declo loam, steep phase												10	10		
Scabland												5	10		
Stony land												5	10		
Riverwash													10		

[1] The soils are listed in the approximate order of their general productivity and suitability for irrigation farming.

[2] The soils of the Aberdeen-Blackfoot area are given indexes that indicate the estimated average production of each crop under irrigation to the nearest 5 percent of the standard of reference. The standard represents the approximate average yield obtained without the use of amendments on the more extensive and better soil types of the regions of the United States in which the crop is most widely grown. Blank spaces indicate that the crop is not commonly grown.

[3] The standards used here for alfalfa seed and clover seed have been selected only on the basis of yields in this area. They are not to be accepted as standards for all sections of the country.

[4] The term "cow-acre-days" is used to express the carrying capacity or grazing value of pasture or range lands. It represents the number of days that 1 animal unit can be supported on 1 acre without injury to the pasture, or the product of the number of animal units to the acre multiplied by the number of days of grazing. The animal unit is a means of measuring the feed requirements of livestock. It is the equivalent of a mature cow, steer, or horse, 5 hogs, or 7 sheep or goats. On semiarid grazing land the ratio is more properly 3 to 5 mature sheep to each cow. For example, a soil that would provide grazing for 1 cow to the acre for 100 days, or for 2 cows for 50 days, would rate 100 cow-acre-days; and 1 cow to 4 acres for 100 days would equal 25 cow-acre-days. Estimates are for normal seasons only and do not include extremely dry years during which there is almost no grass

[5] These numbers indicate the general productivity of the soils for the more important crops of the area. Refer to the text for further explanation.

[6] This is a generalized statement of relative productivity.

[7] These soils are not commonly irrigated at present, and the indexes are estimates of potential yields under irrigation.

[8] Indexes given for these soils apply to yields obtained only from the better drained areas that are comparatively free from an accumulation of salts.

[9] Sagemoor fine sandy loam, steep phase, is used to some extent for alfalfa hay and seed as well as pasture; but, owing to difficulty of handling farm machinery, distributing irrigation water, and controlling erosion, it is grouped with the fifth-class soils.

values except in a very general way. Distance to market, relative prices of farm products, and other factors influence the value of land. It is important to realize that productivity, as measured by yields, is not the only consideration that determines the relative worth of a soil for growing crops. The ease or difficulty of tillage, the ease or difficulty with which productivity is maintained, and in this area the ease of distribution and the efficiency of use of water are considerations other than physical productivity that influence the general desirability of a soil for agricultural use. In turn, steepness of slope, presence or absence of stone, resistance to tillage offered by the soil because of its consistence or structure, and size and shape of areas are characteristics of soils that influence the relative ease with which they can be tilled. Likewise, the inherent fertility and susceptibility to erosion are characteristics that influence the ease of maintaining soil productivity at a given level. Productivity, as measured by yields, is influenced to some degree by all these and other factors, such as the moisture-holding capacity of the soil and its permeability to roots and water; therefore, they are not factors to be considered entirely separately from productivity; but, on the other hand, schemes of land classification or groupings of soils to designate the relative suitability of land for agricultural use must give some separate recognition to them. The right-hand column of table 6 gives a classification or grouping of the soils of the Blackfoot-Aberdeen area on the basis of their general productivity and suitability for irrigation agriculture. A brief explanation of the more important characteristics of the soils within each group is also given. It will be seen that the first three classes of soils are those to which irrigation farming is almost entirely restricted.

SOIL MANAGEMENT, LAND USE, AND FARMING METHODS

The aim of efficient land use and good soil management is to produce a good income over a period of years and at the same time to keep up the productivity of the soil. This requires use of the land for the purpose or purposes for which it is best suited, the adoption of suitable types of farming, the growing of the crops that are best adapted, and the use of such methods of soil management—including irrigation, crop rotation, tillage practices, and application of manures and fertilizers—as will maintain or build up the fertility of the soil and minimize erosion. In order to practice good soil management, the farmer needs to take into consideration a soil's good points and its deficiencies and to make use of the former and overcome the latter.

Land use has been discussed in the sections on Soil and Crops and Productivity Ratings and Physical Land Classification, and so it will not be discussed in detail here. It will merely be stated that in general the fine-textured soils of the uplands, terraces, and well-drained bottom lands are well suited to general farming and to the growing of a wide variety of crops under irrigation. The very sandy soils, which are mainly on the terraces, are adapted either only to grazing or to the production of alfalfa, mainly for seed; the wet soils of the bottom lands are suited only for wild hay and pasture; and the rougher and steeper lands either are suitable only for grazing or may be used in a limited way for production of alfalfa and other crops that do not require frequent tillage. Scabland, stony land, riverwash, and rough

broken land are virtually wasteland, although they have some value for grazing.

The soils of the Blackfoot-Aberdeen area are, with the exception of a comparatively limited acreage of wet bottom land, too dry to produce crops without irrigation and, in their virgin state, too low in content of organic matter and nitrogen to produce very high yields, even where ample water is applied. They are, however, rich in mineral plant nutrients, and, by proper soil management, including crop rotation and use of manures, they can be built up to a high state of productivity under irrigation. Once a satisfactory level of productivity is attained, consistent good management is needed to maintain it. Phosphorus, although ordinarily present in the soils in considerable quantity, may not be available in sufficient quantity to satisfy the requirement for heavy yields of some crops. This lack of availability of phosphorus is due largely to the high lime content of the soils and irrigation waters, which keeps the phosphates in insoluble form. This deficiency may be overcome to a considerable extent by the application of manure and superphosphate or other readily soluble phosphate fertilizer.

It is common knowledge that alfalfa in the crop rotation is the best and most economical agent for supplying nitrogen and increasing the organic-matter content on an extensive scale. Other legumes, such as red clover and sweetclover, always have been of secondary importance. The proper balance between livestock and cultivated acreage in order to build up and maintain fertility with barnyard manure is seldom reached because of the prevailing cash-crop system of farming. For this reason manure and other organic residues are sufficient only to supplement fertility created by the growth of alfalfa and other legumes.

It is now generally accepted that in a rotation in which alfalfa occupies the land for a period equal to the time that all other crops occupy it, the organic-matter and nitrogen content can be maintained for satisfactory yields. Supplementary additions of manure produce noteworthy increases in yields.

Commercial nitrogenous fertilizers have not become popular in this area because of the economical way in which nitrogen can be supplied by alfalfa and other legumes. The most successful farmers find it good practice to leave the alfalfa for only 3 years in the crop rotation. After that time the yields of alfalfa decrease, owing to diseases, principally bacterial wilt, which reduce yields both by injuring the foliage and by thinning the stands. An equal length of time for other crops also seems to be a satisfactory practice, because after that time the production falls off rapidly unless fertility is replenished by fertilizers, manures, or further growing of legumes. Some farmers extend this period successfully by the application of barnyard manure to the cash crops or by the growth of sweetclover. Sweetclover is generally planted with small grains and plowed under in the spring of the following year. This practice supplies both organic matter and nitrogen. When red clover is used in place of alfalfa, it is grown for 2 years.

It has been the observation of farmers that 5 to 10 years after the virgin soil has been under cultivation, yields of such crops as alfalfa begin to diminish. Now that some lands have been farmed for 50 years or more, critical reductions in yields of alfalfa have taken place on many farms. Application of triple superphosphate made within the

last few years has demonstrated that a deficiency in soluble phosphate is the main limiting factor, as marked increases followed the application of this material. Analyses indicate that the total phosphate content of the soil is high. No response is obtained from the application of raw rock phosphate, yet increases of 100 to 200 percent in the yields of alfalfa follow the application of 125 pounds of soluble phosphate an acre (*10*). At the Aberdeen substation of the Idaho Agricultural Experiment Station, applications of 800 to 1,000 pounds of finely ground raw rock phosphate an acre on leveled soils of the Declo series having a high content of lime gave no increase, whereas an application of 200 pounds of triple superphosphate did.

Other records at the station indicate that an application of 200 pounds an acre of triple superphosphate on leveled, limy Declo loam and Declo silt loam has increased alfalfa yields 80 percent over a period of several years. Similar application for red clover seed gave twice the yield of the untreated plots.

Extensive tests in the laboratories and in the field on soils throughout this area have indicated that the availability of naturally occurring soil phosphate to plants is linked up with the presence or absence of lime in the soil (*10*). The phosphate, although present in large quantity, is rendered unavailable by the high lime content. Laboratory tests have shown that superphosphate is 200 times more soluble in water than raw rock phosphate. Other tests have shown that natural phosphate is three times more soluble in water saturated by carbon dioxide than in water that contains no carbon dioxide. This indicates that the beneficial effect of organic manures, such as barnyard manure and green cover crops, is due, at least in part, to the formation of carbon dioxide, which acts on the natural phosphate, making it more available.

During the progress of the survey in this area it was observed that almost everywhere the surface soils of irrigated lands contained considerable lime. Originally the undisturbed virgin soils of the uplands and terraces contained little or no lime to an average depth of about 12 inches and in some places to a depth of 18 or more inches. The concentration of lime in the surface soil depends to a considerable extent on the length of time the soils have been irrigated. An endeavor was made to check up on the source of the lime. Analyses of the waters of both the Snake and Blackfoot Rivers showed an average content of about 50 parts of calcium per million of water. Some of the lime accumulated in the surface soils undoubtedly comes from these waters, and probably much comes from the underlying limy subsoils as a result of scraping during the leveling of the land for irrigation, burrowing by rodents, erosion, deep plowing, and capillary rise from the saturated subsoil after heavy irrigation. Whatever may be the source of the lime, the irrigated soils commonly are distinctly to highly calcareous, and as a result the phosphate in the soils is largely insoluble and not available to plants.

Analyses were made of several soils in both the virgin and the cultivated condition. The samples were chosen so as to assure that the corresponding virgin and cultivated soils were identical in their virgin state. Sites were chosen where the undisturbed virgin soil was separated by a fence from the same soil in an irrigated field. The history of the cultivation and irrigation period was also taken. Table 7 shows the results of the investigation.

TABLE 7.—*Fertility changes resulting from irrigation and cropping* [1]

Soil type and condition [2]	Sample No.	Depth	Organic matter	Nitrogen	P_2O_5	pH [3]	$CaCO_3$
		Inches	*Percent*	*Percent*	*Pounds per acre*		*Percent*
Rupert fine sand, rolling phase:							
Cropped (a)	1	0 - ½	1.02	0.0007	648	8.85	0.1250
		½- 6	.58	.0600	668	8.18	.0025
		6 -18	.41	.0288	646	8.30	.0725
		18 -30	.19	.0200	668	8.06	.0076
		30+	.08	.0072	270	9.20	3.6600
Virgin (a)	2	0 - ½	1.18	.0687	744	7.95	.2350
		½- 6	.52	.0395	616	8.24	.0025
		6 -18	.33	.0272	600	8.15	.0297
		18 -30	.25	.0178	658	7.98	.0033
		30+	.11	.0128	262	9.10	6.0000
Cropped (b)	3	0 - ½	2.00	.0824	720	8.86	.5350
		½- 6	.68	.0336	626	8.58	.2640
		6 -18	.41	.0328	606	8.44	.1815
		18 -31	.25	.0328	644	8.20	.0475
		31+	.17	.0120	256	9.17	10.9000
Virgin (b)	4	0 - ½	1.70	.0752	734	7.40	.0066
		½- 6	.47	.0280	718	7.48	.0570
		6 -18	.30	.0280	644	7.54	.0100
		18 -30	.30	.0184	676	8.33	.2500
		30+	.08	.0112	228	9.10	6.6800
Bannock gravelly loam:							
Cropped (a)	5	0 - 1	4.58	.1810	676	8.47	.9600
		1 -10	2.38	.1230	1,194	8.21	.2330
		10+	.44	.0398	174	9.02	16.6500
Virgin (a)	6	0 - 1	5.32	.2000	1,414	8.13	.1900
		1 -10	1.44	.0942	1,256	8.40	.0300
		10+	.82	.0847	181	8.87	7.8000
Cropped (b)	7	0 - 1	3.20	.1750	1,156	8.40	.7470
		1 -10	.72	.0800	1,316	8.40	.3020
		10+	.55	.0448	126	9.30	14.0200
Virgin (b)	8	0 - 1	1.66	.1150	1,476	8.42	.1480
		1 -10	.68	.0710	1,280	8.40	.0060
		10+	.39	.0646	114	9.30	9.9000
Bannock fine sandy loam:							
Cropped (c)	9	0- 2	.94	.0814	1,060	8.98	.3450
		2- 8	.72	.0710	1,140	8.92	.3900
		8-18	.50	.0575	1,142	8.53	.1150
		18+	.16	.0494	108	9.30	13.4000
Virgin (c)	10	0- 2	1.93	.1052	1,600	8.70	.0770
		2- 8	.99	.0805	1,270	8.32	.0000
		8-18	.98	.0638	1,300	8.46	.0100
		18+	1.03	.0622	120	9.35	9.5300
Cropped (c)	11	0- 2	1.83	.0974	1,200	9.03	.5820
		2- 8	1.79	.0960	1,226	8.89	.3900
		8-18	.98	.0622	1,410	8.62	.1020
		18+	.87	.0592	120	9.20	12.3500
Sagemoor very fine sandy loam:							
Cropped (a)	12	0- 1½	2.27	.1165	1,128	8.91	.9070
		1½- 9	1.95	.1124	1,398	8.63	.0420
		9+	1.09	.0622	126	9.90	16.5200
Virgin (a)	13	0- 1½	2.71	.1110	1,370	8.28	.0350
		1½- 9	1.68	.0894	1,256	8.24	.0380
		9+	.87	.0686	126	9.30	14.6800
Cropped (b)	14	0- 1½	1.38	.0926	944	8.63	.8400
		1½- 9	1.30	.0865	1,140	7.08	.0770
		9+	.92	.0840	130	9.06	16.7700
Virgin (b)	15	0-1½	1.35	.0912	1,058	7.90	.0000
		1½- 9	.85	.0664	1,040	8.20	.0470
		9+	.92	.0766	168	9.50	14.1200
Cropped (c)	16	0- ¼	1.89	.1325	1,000	8.52	.2770
		¼- 8	1.46	.1015	1,298	8.36	.0320
		8-26	.98	.0760	1,370	8.30	.0350
		26+	.59	.0544	208	9.02	12.0700
Virgin (c)	17	0- ¼	4.22	.1840	1,442	7.63	.0370
		¼- 8	1.40	.0880	1,116	7.73	.0000
		8-26	.88	.0744	1,218	7.69	.0000
		26+	.65	.0528	184	9.00	17.8200
Cropped (c)	18	0- ¼	1.89	.1100	964	8.00	.2950
		¼- 8	1.57	.0992	1,018	8.10	.0320
		8-26	1.08	.0815	1,220	7.92	.0000
		26+	.78	.0618	126	8.86	17.7000

[1] Analyses by Department Agricultural Chemistry, University of Idaho.
[2] Letters in parentheses indicate corresponding virgin and cultivated soils.
[3] By glass electrode method.

The effect of a 5-year irrigation on Rupert fine sand, rolling phase, in two situations (samples 1 and 3) is shown as compared with the corresponding virgin soils (samples 2 and 4). In both situations

the increase in both lime and pH (alkalinity) is noteworthy above the natural zone of lime accumulation. The increase in the surface crust is especially marked. The decrease in soluble phosphate is indicated but is not marked because of the short period of irrigation and the low lime saturation. Increase in nitrogen from the 5-year growth of alfalfa is suggested, but the organic-matter content has not been changed materially.

The effects of a 10-year irrigation on Bannock gravelly loam in two situations (samples 5 to 8) is shown. The increase in lime above the layer of lime accumulation is noteworthy, though the increase in pH is not so marked as in the Rupert soil. The decrease in soluble phosphate with increased lime is noteworthy. The increase in organic matter indicated in samples 7 and 8 is very marked. The cropped soil has been in alfalfa almost continuously. In the case of samples 5 and 6, grain and cash crops had been grown on the cropped land for several years, so that any increase resulting from the growing of alfalfa had been depleted.

Sample 10 represents the virgin profile of Bannock fine sandy loam, and samples 9 and 11, taken nearby, had been irrigated and cropped for about 20 years. In both situations the increase in lime and pH is marked and the consequent decrease in soluble phosphate is obvious. Both of the cultivated soils had been producing grain and cash crops for only 4 or 5 years; therefore the organic matter and nitrogen are near the virgin levels.

In samples 12 and 13 of Sagemoor very fine sandy loam, the increase in lime and pH is very marked in the cropped soil, and the resulting decrease in soluble phosphate is noticeable. This field had been irrigated for a period of about 15 to 20 years, the last 4 years being devoted to cash and grain crops. The result of the 4-year cropping is indicated in the nitrogen and organic-matter content, which are reduced to those of the virgin condition.

Samples 14 and 15 of Sagemoor very fine sandy loam show the increase in lime and pH resulting from a 15-year irrigation and cropping period. This field had been in alfalfa for several years, and the organic matter and nitrogen are shown to be increasing.

Sample 17 represents virgin soil and samples 16 and 18 the corresponding cultivated soils nearby. Both of these cultivated soils had been cropped for about 15 years, and both show an increase in lime and pH and a decrease in available phosphate resulting from irrigation. Below the surface crust the organic matter and the nitrogen appear to have increased slightly.

These results indicate conditions resulting from 20 years or less of irrigation and cropping. Most of the soils of the area have been farmed from 25 to 50 years. After such a period most of the soils have become highly calcareous throughout and effervesce vigorously with acid. Where these conditions are the more pronounced, yields of alfalfa, clover, and sugar beets are reduced materially, and excellent responses are obtained from the application of superphosphate.

The rate and frequency of application of the triple superphosphate needed to obtain best results have not been determined satisfactorily, but indications are that light frequent applications are more satisfactory than heavier applications at longer intervals. Apparently

this is because the lime quickly renders the surplus phosphate insoluble. The quantity of phosphate needed will vary with individual fields according to the lime content of the soil and within the fields because of uneven distribution of lime in leveling. The more limy areas may need an additional application to establish an equilibrium so that sufficient phosphate is available for the plants. On calcareous soils, especially those of high lime content, applying barnyard manure or plowing under green cover crops will increase the availability of the natural phosphate and tend to maintain the availability of applied phosphates because of the carbon dioxide created in decomposition of the organic residues. Carbon dioxide reduces the alkalinity, which is shown to increase with irrigation. Plants are known to suffer from lack of nutrients other than phosphorus under highly alkaline conditions.

Present investigations at the Aberdeen substation and observations in the field indicate that superphosphate should be applied for alfalfa, red clover, and sugar beets, especially on the more limy soils, but that under a balanced system of crop rotation the other crops have not yet shown increases sufficient to warrant its use.

Alfalfa of the hardy Grimm variety is grown almost exclusively in the district southwest of Blackfoot, which produces most of the alfalfa seed of the area. Here the Ladak variety is also grown for seed on a small acreage. North of Blackfoot both Grimm and Common alfalfa are grown. The Grimm variety, because of its lateral root system, withstands winter-killing better than the Common variety, which has a taproot. The growers of Grimm alfalfa seed are organized and supply Midwest markets with certified seed. Ladak seed also is certified, but the demand in the Midwest does not warrant increased production. Ladak, although hardy, is not popular because of its slow growth. At the Aberdeen substation for a 4-year period Ladak outyielded Grimm for hay by 7.4 percent (*3*). Grimm has consistently outyielded the Common variety, sometimes nearly double yields being obtained.

Bacterial wilt and in some localities the alfalfa weevil reduce yields of both hay and seed. The production of alfalfa seed is a rather complicated process requiring considerable experience (*8*). Dry seasons and well-drained sandy or medium-textured soils seem to be most favorable. Some of the more rolling or sloping soils produce seed very successfully. This information was obtained through experiments at the Aberdeen substation on the Declo soils and from observation on the adjacent Sagemoor soils.

Alfalfa is usually seeded with a small-grain crop as nurse crop. The rate of seeding is 10 pounds for hay and 2 or 3 pounds for seed. The alfalfa matures two full cuttings of hay and a third that varies in size with the length of the season. The latter is usually immature when cut for hay or pastured.

Medium red clover for seed is the most extensively grown of the clovers (*9*). Idaho Commercial has been the best variety at the Aberdeen substation and is the principal variety grown. Clover is seeded at the rate of 10 pounds an acre in the same manner as alfalfa. It is clipped or pastured until the first of June; then it is allowed to grow for seed. This practice controls the aphid and to some extent the mildew by which it is attacked (*9*).

Sweetclover, which is grown principally for pasture, is of the biennial white or yellow types. The former is the heavier producer and the more popular. The manner of seeding and the rate per acre are the same as for alfalfa. This is a very successful green cover crop when seeded with small grains and plowed under the following spring.

Wheat is largely of the Federation variety, but there is a considerable acreage of Dicklow. Federation is the highest yielding. It has short, stiff straw and small heads, which prevent lodging on the more fertile soils. On the less fertile and light sandy soils Dicklow grows taller and is preferred. Dicklow has a better quality grain. A Dicklow-Federation cross is high yielding and is showing much promise at the Aberdeen substation. This cross has the stiff form of straw and the early maturity of Federation and the color and quality of grain of Dicklow.

Wheat is seeded as early as possible in the spring and is harvested from August 1 to August 10. The rate of seeding is 90 to 100 pounds an acre. Wheat is subject to attack by rust and smut. Seed treatment is usually made with formaldehyde, copper carbonate, or mercuric compounds (*4*).

The high-yielding Trebi barley, developed at the Aberdeen substation, is grown almost exclusively. Barley is planted as early as possible. The rate of seeding is 90 to 100 pounds an acre. Harvest takes place the latter part of July. Rust and smut also attack barley, and the seed is treated in the same manner as wheat seed.

The Victory variety of oats is the most popular and is grown extensively. A new variety, Bannock, developed at the Aberdeen substation by crossing Victory and Markton, was released in 1937. This is a high-yielding smut-resistant variety. Seed treatment of oats is the same as for wheat and barley. Oats are sown as early as possible and harvested the first of August.

Owing to the importance of the potato crop in this area, a good deal of attention is given to the quality of seed and freedom from disease. Proper crop rotation reduces disease to a minimum. Roguing reduces the spread of the various diseases. Most of the roguing is done in special seed plots. Certified seed is brought in from disease-free districts to the north, and most of the seed plots are from such seed. Extensive planting from directly introduced seed is seldom made.

Potatoes usually follow alfalfa in the rotation. Often alfalfa is plowed in during the spring, and this practice gives additional green manure from the early growth. Potatoes usually follow alfalfa for 2 years or more, or sugar beets are planted the second year. Where potatoes are grown for more than 2 years, barnyard manure or green manure is usually used to keep up the fertility. In a rotation including red clover, potatoes follow this crop. Potatoes do best on the medium- to light-textured soils. Heavy soils dry out and become hard between irrigations, causing irregular growth and reducing the salable product. It is important to irrigate regularly every 7 to 10 days in order to maintain a uniform growth. Cultivation follows irrigations as long as the vines allow.

The Russet Burbank (Russet) potato, a late variety, is grown most extensively. Triumph (Bliss Triumph) and Charles Downing (lo-

cally known as Idaho Rural or Rural) are the early varieties grown. A considerable acreage throughout the county is devoted to the latter variety, but only a few small areas produce Triumph. The Idaho Rural potatoes are usually planted May 1 and Russet from May 10 to May 30. Most of the acreage in the Idaho Rural variety is harvested for the early market in late August and in September. The earliest harvest of Russet potatoes begins after the first of October, and later digging continues into November. The rate of seeding of all varieties is from 1,000 to 1,200 pounds to the acre. Very little seed is treated, but, when this is done, corrosive sublimate or formaldehyde is used (*9*). Fusarium wilt is the worst disease of the Russet and mosaic spindle tuber and blackleg of the Idaho Rural, although both varieties are attacked by these plant diseases. Rhizoctonia and common scab also reduce the salable quantities of potatoes.

New varieties of sugar-beet seed developed by the United States Department of Agriculture (*18*) are resistant to curly top, a virus disease transmitted by the beet leafhopper. Sugar beets are planted as early in the spring as possible. Triple superphosphate is usually applied with the seeding at the rate of 70 pounds an acre. Most of the harvesting takes place in October and November. Sugar beets seldom follow alfalfa in rotation, as the alfalfa roots interfere with uniform seeding and cultivation practices. They usually follow potatoes. High fertility is necessary for good yields, and, in addition to the superphosphate, most of the barnyard manure is applied for this crop. The medium-textured soils usually produce the largest yields.

Peas are usually grown under contract as seed peas for various seed companies. Most of them are of the garden varieties, and only a very few field peas are produced. The field peas are of the Kaiser variety. The garden peas include such varieties as Everbearing, Perfection, Stratagem, Alderman, and Thomas Laxton. Peas are planted as early as possible and harvested July 20 to August 10. They are considered useful to increase the nitrogen content of the soils and usually are followed by potatoes. Garden peas are considered a good nurse crop for alfalfa and clover, but field peas have too heavy foliage for this purpose. Care must be used in irrigation, as scalding affects the seed pods when flooding is practiced. When planted on well-elevated ridges between the furrows this danger is minimized. Fusarium wilt also attacks the peas (*19*). Where this disease is prevalent, wilt-resistant varieties should be planted. Aphids reduce yields in some years.

Garden beans are grown for seed under contract. Only a small acreage is devoted to the dry edible commercial varieties of Pinto and Idaho No. 1 Great Northern. The Golden Wax variety of garden beans is the most popular. Beans are usually planted after danger of frost is over, preferably in the latter part of May. Harvest takes place early in September. It is essential to plant beans on high ridges to prevent scalding as in irrigation of peas. Beans are attacked by the leafhopper. Mosaic is also a serious problem in some years. The Idaho No. 1 Great Northern variety, developed by the Idaho Agricultural Experiment Station, is resistant to this disease (*19*).

Besides the usual methods of weed dissemination, irrigated areas are confronted with the problem of rapid spread of noxious weeds by irrigation water. Ditch and canal banks are very fertile places for

the propagation of weeds. The noxious weeds that are difficult to keep under control in this area include quackgrass, wild morning-glory, Canada thistle, whitetop, povertyweed, and Russian knapweed (*2*, *17*). Whereas most weeds can be controlled by crop rotation and cultural practices now in common use, these noxious weeds survive from year to year because of the creeping horizontal roots and rootstocks, which are difficult to control and are spread throughout the fields by farm implements. Clean cultivation is sometimes employed satisfactorily, but along ditch and canal banks and heavily infested areas the application of chemicals gives quicker and more satisfactory results. Chlorates in dry form and as sprays have proved effective and are commonly employed. Carbon bisulfide is coming into more common use under moist soil conditions. Common salt is used less frequently because of the detrimental effect on the soil.

Livestock enterprises are necessary for a balanced agriculture. A sufficient quantity of organic matter for high productivity is seldom maintained in the soil without the use of barnyard manure. Few farms have sufficient livestock to keep up a properly balanced fertility throughout the farm unit. The use of commercial fertilizers alone will nearly always fall short of this purpose, and the organic matter (humus) as a reservoir for both plant nutrients and moisture will be seriously lacking. Farms on which sufficient livestock has been kept so that at least one application of manure has been made for cultivated cash crops in each rotation with legumes have the most productive soils after extended periods of cropping. Many farmers have profited by the feeding of range cattle and sheep on their lands.

Although tractors are becoming more common, draft horses are still the main source of power. The horses are predominantly of Belgian breeding, but there are few purebred animals except the sires. Probably about three-fourths of the stallions are of this breed.

Dairy cattle are kept on most of the farms, and many of the farmers sell the dairy products through cooperative agencies. When soil fertility is taken into consideration, together with the constant income, dairying offers inducement for expansion on most farms. The Holstein-Friesian breed predominates, with Jerseys next in importance. Guernseys are common in some parts of the area. There are only a few purebred herds, but good sires are kept on most farms.

Beef cattle are less common on the farms, though range cattle are frequently brought in for winter feeding. Herefords predominate, and purebred sires are usually maintained.

Sheep raising is next in importance to dairying, and farm flocks are becoming more common. Besides consuming the surplus hay grown in the rotation, sheep also graze ditch banks and other areas, thus controlling weeds to a large extent. Fields producing alfalfa and clover seed are often grazed by sheep until June 1 to June 10. Much of the grain grown on the farms is used in fattening lambs. There appears to be much room for expansion of this enterprise, because most of the surplus hay and fall pasturage is now consumed by range sheep brought in for winter feeding. Both this enterprise and dairying offer possibilities for better distribution of labor and more diversified income throughout the year than is customary on the average farm, as well as for maintenance of soil fertility.

Purebred Hampshire rams are kept for the production of spring lambs for market, but Corriedales are more common for maintaining white-faced ewes for wool and breeding stock. Most farm flocks have their origin from range ewes of long-wool breeds crossed with Rambouillets. Wool and lamb pools are organized as marketing agencies.

On many farms hogs are raised both for home consumption and for market. They are often kept on alfalfa pasture. In the fall they feed on sugar-beet tops and other harvest residues. A considerable quantity of small grains is used in finishing them for market. Duroc-Jerseys are the main breed, but Poland China and Chester Whites are raised on some farms. Purebred boars or boars of good breeding are usually kept. A few farmers raise purebred hogs, but this is not the common practice.

Chickens are kept on most farms. They supply poultry products for home use and provide additional revenue throughout the year. Some farmers produce them on a commercial scale. White Leghorns are the most common breed, and some Rhode Island Reds, Plymouth Rocks, and Buff Orpingtons are raised.

IRRIGATION, DRAINAGE, AND ALKALI[9]

Irrigation is necessary in this area for the successful production of crops, except on comparatively small areas of wet bottom lands where wild hay is produced. The diversion of water for irrigation, mainly from the Snake and Blackfoot Rivers, began with the earliest settlement. Springs and underground flows are almost negligible as a present source of water, although they offer possibilities for development in parts of the area having later and more limited river diversion rights. The practicability of pumping to augment this supply has been demonstrated during dry years.

The right to divert water from the Snake and Blackfoot Rivers is established by law. The date of issuance of decrees establishes the priority of water rights. The earlier water rights are certain of delivery of water throughout the year, but those of later date may not have a sufficient supply of water by gravity to mature fully all crops during years of low precipitation. Failure of a supply rarely occurs at present. Reservoirs have been built, and some canal companies have such storage rights. thus insuring delivery of water for irrigation in the latter part of the season when the natural flow is small. Leased water can also be obtained from canal systems that have water rights in excess of their own needs. An exchange of water has also taken place since the American Falls Reservoir was completed. Various canal companies operating in the area own rights to storage water in this reservoir; and, although the reservoir lies below the diversion points of the canals, exchange is made for Jackson Lake water stored on South Fork Snake River.

Allocation of the water of the Snake River Basin is under the supervision of a watermaster who is employed jointly by the United States Geological Survey, the Idaho Department of Reclamation, and the water users.

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[9] The term "alkali" is used in this section in its popular or agricultural sense to include toxic accumulations of soluble salts that may include both neutral salts and alkaline salts. or true alkalies.

Most of the decrees for diversion of irrigation water were issued between 1884 and 1903. Many canal systems are now in operation. These are shown on the accompanying soil map. They are cooperatively owned and financed by the farmers. Those within the Fort Hall Indian Reservation are operated by the United States Office of Indian Affairs.

Water diverted from the Blackfoot River serves both the reservation and certain adjacent lands farmed by white settlers. Some of the white settlers own or lease lands within the reservation. The Blackfoot Reservoir, with a storage capacity of 418,000 acre-feet, serves both the reservation and the other land.

Grays Lake storage water and 600 second-feet of water diverted from the Snake River also serve the Fort Hall Indian Reservation. Active construction for this diversion of water for irrigation on the reservation began in 1907, but all work was not completed until 1928. The present project is designed to serve 60,196 acres, but part of this lies outside the area surveyed.

In 1937, 110,174 acres in this area, outside of the reservation, were irrigated by gravity diversion. In some districts water must be elevated by pumping. These pumping projects serve 6,503 acres.

The duty of water, or water requirement, refers to the quantity of water required to mature various crops. This varies with the crop and with weather conditions, and theoretically it should not vary greatly between different soil types. As a matter of fact, widely different quantities of water are used on different soils, owing to their different moisture-holding capacity and porosity and to unavoidable losses by deep percolation and evaporation in the frequent irrigations of the sandier and shallower soils. The moisture-holding properties vary greatly with the texture and depth of the soil and the character and compactness or porosity of the underlying material. In general, economy of water per unit of product is greater on the loessial soils of the uplands and the soils of the lake terraces than on the soils of the gravelly alluvium (Gibson terrace), and much greater than on the very sandy soils. The range of water requirement on soils of the bottom lands is wide.

Water used in irrigation is usually measured in acre-feet. One acre-foot would cover an acre to a depth of 1 foot. The average quantity of water used is probably between 3 and 4 acre-feet, although it ranges from 2 to 8 or more acre-feet. This refers to water delivered to the farm and not storage water. There is considerable loss in delivery of water, through evaporation and seepage.

Water is applied both by flooding between borders (the flooding or border method) and through furrows. Alfalfa, clover, and grains usually are irrigated by the former method, and potatoes, sugar beets, and other intertilled crops by the latter. On the less uniform areas furrows or corrugations are used for all crops, in order to spread the water more uniformly and to allow water to follow the contour of the land to reduce erosion. Corrugations are frequently used between borders to facilitate distribution and saturation. Occasionally borders are used together with furrows for intertilled crops.

Drainage problems in this area are confined to comparatively small districts that were affected to some degree by some seepage and accumulation of alkali before the development of irrigation, but that

have become enlarged and increasingly affected through waste water and seepage from irrigation canals, usually arising from sources outside the affected area. Most of the areas affected by seepage are the result of very slowly permeable clay strata over which percolating waters accumulate, saturate the surface soil, and move horizontally, seeking outlets at lower elevations. Where there is no such outlet, the soil becomes waterlogged; and where there is such an outlet, the adjoining soils at lower elevations become saturated with the seepage water and with the soluble salts dissolved in it.

Such conditions are common on the Sterling terrace and to a less extent on the adjoining Grandview-Pingree and Aberdeen terraces, which are underlain by lake-laid materials. The Sterling terrace is underlain by massive almost impermeable clay to a depth of 20 to 30 feet or more. Most of the water moves horizontally and cannot find an outlet because of the higher areas underlain by this clay north and south of Sterling. Few natural drainageways cross this clay area, and these have not cut deeply enough to carry off the excess surface water. The few local surface drains that have been installed are inadequate. The expense of installing an adequate and comprehensive drainage system probably would far exceed the value of the land served. Furthermore, the drainage is not at an equilibrium yet, as the water table is still rising, being constantly fed by seepage from the adjoining irrigated territory. The water table has risen 20 feet since 1919.[10]

The Grandview-Pingree terrace west of Springfield is affected by seepage and alkali extending along draws and depressions. Because of the slope and available outlet for drainage waters, the installation of deep system of drains would probably be sufficient here for reclamation or the prevention of further spread.

On the Aberdeen terrace there has been a rise of about 5 feet in the water table since 1919.[10] Originally seepage and alkali accumulations were confined largely to the nearby coulee bottoms, but these conditions now endanger the adjoining territory. Increasing the depth of the natural drains at Aberdeen and 2 miles south of that place appears to be inadequate, and a deeper and more elaborate system may be necessary. Within a radius of about half a mile or so of Aberdeen, clay strata restrict free movement of water, and evidence of alkali accumulations is discernible in spots. A similar area is southeast of that town. Such areas may require individual farm drains in the future, if drainage conditions do not soon become stable.

On all these terraces the water table fluctuates with the irrigation season. It is lowest during April and May and is highest in September and October.

East of Blackfoot in the sand-dune district, the underlying subsoil and substrata include clays, which force water upward, causing waterlogging and an accumulation of surface water. This condition also fluctuates with the irrigation season and seems to be fed by the old Sand Creek channel, now used as an irrigation canal. Most of the areas in this locality are almost completely surrounded by sandy dune-like areas, and the installation of a drainage system would in most places be prohibitive because of the small areas involved.

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[10] See footnote 2, p. 3.

Drainage on the bottoms of the Fort Hall Indian Reservation is apparently at equilibrium with the seepage and water from springs that feed it, as the seasonal fluctuation of the water table is small. Drainage is practically impossible, because of the preponderance of water that issues from springs. This area is a native-hay meadow on which no drainage development is desired or necessary, because more hay and pasture are provided under existing conditions than could be obtained if the land were drained.

Associated with all the poorly drained areas are excessive concentrations of soluble salts that are more or less toxic to plant growth, although some native plants tolerate high concentrations. In their virgin state, many of the soils contain comparatively high concentrations in the subsoil, but the toxic accumulations have largely been brought on since the introduction of irrigation. Localized concentration has been intensified by excess irrigation water and seepage. Areas thus affected are locally known as alkali areas or alkali soils, in which the salts include both the saline salts (white alkali) of chlorides and sulfates and the alkali carbonates (black alkali).

Extensive investigations by the Idaho Agricultural Experiment Station in southern Idaho have indicated that the predominant salts are sodium carbonate, sodium chloride, and sodium sulfate (*13*, *14*, *15*). The latter two usually occur in combination and are referred to as white alkali. Sodium carbonate (black alkali) in many places occurs in association with these salts, but it is localized mainly in various localities on the Sterling terrace.

Plants vary considerably in their ability to withstand excessive accumulations of salts. Degree of toxicity also varies with the nature of the salt, the composition and structure of the soil, and the salt concentration and its localization in the soil profile. Tolerance studies by the Idaho Agricultural Experiment Station on a silt loam from southern Idaho indicate the effect the various salts may have on plant growth. The maximum tolerance of alfalfa for sodium carbonate, which under most conditions is the most toxic salt, was 0.2 percent. With sodium chloride there was normal growth up to 0.16 percent. A concentration of 0.74 percent of sodium sulfate had no material effect.

Sodium carbonate affected wheat at 0.1 percent. At 0.2 percent toxicity was decidedly evident, and at 0.3 percent the crop failed. A 0.2-percent concentration of sodium chloride affected growth, and a 0.25-percent accumulation proved very toxic. A concentration of 0.75 percent of sodium sulfate showed no effect.

Barley was definitely affected at 0.17 percent of sodium carbonate, and the crop failed at 0.3 percent. A 0.3-percent concentration of sodium chloride was toxic, and 0.56 percent was critical. Sodium sulfate showed toxicity at 1.5 percent, and at 2.16 percent plants died.

Oats showed toxic effect from a 0.15-percent concentration of sodium carbonate. With sodium chloride, toxicity was very pronounced at 0.2 percent. Sodium sulfate began to be toxic at 1.5 percent.

During the progress of the survey, areas affected by accumulations of salts were delineated on the soil map. These were outlined on the basis of the salt concentration as indicated by plant growth, soil structure, and surface accumulations, and were checked by determination of total salts in the air-dry soil by means of the electrolytic bridge. As a result, strongly affected areas are included in solid red boundaries

and lettered A, slightly affected areas are included in broken boundaries and lettered S, and salt-free areas are lettered F. Results of determinations by the electrolytic bridge are shown in the form of a fraction in which the number above the line indicates the concentration of total salts in air-dry soil to a depth of 1 foot, and the number below the line shows the average concentration to the depth sampled. Where followed by the letter B, carbonates or black alkali salts were found in combinations. The concentrations and combinations shown are indicative only of conditions in the immediate vicinity of sampling, as great variability occurs from place to place.

In the salt-affected areas there is indication that the dominant salt controls the toxicity. As salts of this area always occur in combination, the more common sodium chloride and sodium sulfate association must be considered in most places. Where sodium carbonate is also present, as on the Sterling terrace, the toxicity is increased rapidly. In salt combinations sodium carbonate is usually considered to increase the toxicity by three. In such places 0.15 percent of salts usually marks the limit of uninhibited growth. Without sodium carbonate the saline salts generally are considered nontoxic at concentrations less than 0.2 percent; 0.3 to 0.4 percent of salts is usually critical to plant growth; and a concentration of 0.5 percent is usually fatal to cultivated crops or the germination of seeds.

Draining the soil and leaching out the soluble salts is the only practicable method of reclaiming affected soils. If good subdrainage can be established by artificial means and excess water removed, effective removal of the salts by leaching without chemical treatment is possible, provided the black alkali salts are absent, on all but the most seriously affected areas.

In the soils of the Blackfoot-Aberdeen area, however, most of the seriously affected areas are underlain by comparatively impervious clays, in which drainage by artificial means would be expensive and perhaps ineffective. Furthermore, in many of the local ponded depressions surrounded by wind-drifted dunelike areas, outlet for drainage waters could be provided only at an expense that present economic conditions do not justify.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of forces of weathering and development acting on soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on the physical and mineralogical composition of the parent material, the climate under which the soil material has accumulated and existed since accumulation, the plant and animal life in and on the soil, the relief, or lay of the land, and the length of time the forces of development have acted on the material. External climate is less important in its effects on soil development than is internal soil climate, which depends not only on temperature, rainfall, and humidity, but on the physical characteristics of the soil or soil material and the relief, which, in turn, strongly influences drainage, aeration, run-off, erosion, and exposure to sun and wind.

The Blackfoot-Aberdeen area lies in the eastern section, known as the Snake River Plain, of the Columbia Plateaus physical province and is characterized by an arid or semiarid cool-temperate climate.

The soils are Pedocals and, according to Marbut (*12*), are Northern Gray Desert soils. The outstanding process in soil formation is calcification. The zonal soils apparently are Sierozem or Desert soils, although they closely resemble the Brown soils (*6*). The intrazonal and azonal soils are Solonchak and other soils that have failed to develop the normal zonal profile because of imperfect drainage, steep slopes, excessively sandy parent materials, or insufficient time. Many areas of the Solonchak soils are in a transitional stage resulting from recent salinization as a result of irrigation and include a variety of soils that had well-developed differentiating characteristics before this environmental change.

The parent materials of all the soils have been transported. The transporting agencies are water and wind, and intermixed water-laid and wind-laid deposits occur throughout the area. Water-laid materials are derived from the basins of the Snake, Blackfoot, and Portneuf Rivers and a few minor tributaries. They consist of a wide variety of rock materials, in most places intimately mixed, and in many instances not readily identified petrographically or mineralogically. The water-laid deposits are in the form of gravelly or sandy alluvium and fine lake-laid strata. (See fig. 2, p. 5.) These overlie the extensive basalt lava flow of the Snake River Plain, which in places is only thinly buried or is exposed. Fragmentary basaltic material occurs in places throughout the soils and makes up much of the gravelly substrata. Mansfield (*11*) attributes much of this dark sand to volcanic latite. Much of the gravel is quartzite, which ranges in color from very light or almost white to gray or, in places, red.

The water-laid deposits have been considerably shifted and sorted by wind action, and wind-borne loess is superimposed in many places on them and on the adjoining basaltic plains. The loess deposits are of indefinite origin, arise principally from sources west of the area, and are much mixed mineralogically. Loess deposits and admixture of loessial materials make the soils more uniform throughout the area. Unmodified deposits of loess are highly calcareous.

In this semiarid climate the light precipitation is subject to rapid evaporation, and its effectiveness in leaching the soil and in supporting vegetation and micro-organisms is at a minimum. The sparse vegetation, consisting principally of sagebrush and some very thin stands of bunchgrasses, contributes very little organic residue to the soil. Neither does it contribute materially to the circulation of bases through the soil, in growth or decay, or release appreciable carbonic acid to promote their mobility. Micro-organic life as a constructive force in soil development is also comparatively ineffective. A large part of the precipitation comes as snow during the winter when the ground is frozen, so that the period of active penetration and leaching is definitely reduced, even though accelerated leaching is promoted for a short period when spring thaws set in.

Relief and texture further control the degree of moisture penetration and erosion.

With the constructive biological forces in soil development held to a minimum by the arid climate, inorganic physical and chemical activities apparently are dominant in the evolution of the soils. The mechanical forces that result in the disintegration, sorting, deposition, and stratification of soil materials include water, wind, and tem-

perature changes, and the chemical forces include hydrolysis, solution, precipitation, hydration, dehydration, carbonation, and oxidation, all processes directly associated with weathering and soil development.

According to Nikiforoff (*16*), hydrolytic decomposition followed by dehydration causes the clay concentration in the profile of Southern Desert soils, and compounds accumulate from rising solutions to form the hardpan layers. He states that the immediate surface horizon is passive, that is, without hydrolytic activity as a result of rapid vaporization, which also causes precipitation of compounds from rising solutions in the horizons below.

The Northern Desert soils are probably subject to the same soil-development processes; but because of the cooler, temperate climate, chemical changes are slower and rainfall is more effective owing to reduced evaporation. Oxidation does not produce an appreciable red color in the soils. The effects of carbonation are most definitely impressed on the profiles. The alkaline earths are carbonated from descending and ascending solutions into a zone of accumulation between depths of about 1 and 4 feet.

Chemical analyses in table 8 show these carbonates to be calcium carbonate and magnesium carbonate, the former predominating. Normally, under virgin conditions, the soluble salts of the monovalent bases are removed from the surface horizons above the lime layer, but in many places they show a slight concentration in the latter. Free carbonates are absent from the surface horizons or are present only in small quantities, as indicated by test with dilute hydrochloric acid and laboratory determinations. (See table 7, p. 93.)

TABLE 8.—*Chemical analyses of a sample of the profile of Portneuf silt loam from the Twin Falls area, Idaho* [1]

Sample No.	Depth	SiO_2	TiO_2	Fe_2O_3	Al_2O_3	MnO	CaO	MgO	K_2O
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
540901	0–3	72.44	0.64	3.92	12.16	0.06	2.04	1.47	2.57
540902	3–14	68.69	.65	4.30	12.91	.05	2.73	1.75	2.42
540903	14–36	58.06	.49	3.10	9.67	.05	10.80	3.41	1.98

Sample No.	Na_2O	P_2O_5	SO_3	Ignition loss	Total	N	CO_2 from carbonates	Organic matter	H_2O at 110° C.
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
540901	1.77	0.17	0.13	3.63	101.00	0.07	--------	--------	2.05
540902	2.01	.20	.08	4.85	100.64	.08	--------	--------	3.20
540903	1.80	.18	.20	11.30	101.04	.03	8.42	--------	2.10

[1] Analyses made by G. J. Hough, Aug. 9, 1921 (*1*, p. 1390).

There seems to be sufficient evidence in unmodified parent materials to indicate that, in the dominant fine-textured soils, soil development began on calcareous materials. Therefore definite leaching obviously takes place, even though the rainfall is low and evaporation comparatively high. Apparently some translocation of clay also occurs with this leaching. The extent to which organic matter accumulates in the surface soil is indicated in table 7.

The abrupt upper limit of the layer of pronounced lime accumulation and its high concentration is shown in table 7. Likewise the high

pH values resulting from the concentration are indicated. In the upper 3 or 4 inches, the lime layer is compact and platy, and the plates have overlapping or dovetailed edges. Below this it is less compact and contains densely massed spherical nodules from one-half to three-fourths of an inch in diameter. With depth the density decreases and the spherical units are less definite though evident. Centers of the fractured units are of lower lime content.

The regional profile is most typically developed in soils of the Portneuf series. These soils, developed from loessial parent materials, are free from abnormal conditions of drainage, relief, and other factors limiting soil development, and therefore are normally developed soils in equilibrium with the environment.

Following is a description of a selected profile of virgin Portneuf silt loam:

1. 0 to 4 inches, noncalcareous light grayish-brown silt loam with a 2-inch surface layer of soft fragile vesicular geometric slabs capped by a platy crust.
2. 4 to 14 inches, noncalcareous light-brown silt loam that is slightly heavier textured than the overlying material and slightly compact yet friable and mellow. This layer has no distinct structure but breaks into large irregular prismatic chunks and contains root and insect channels and smaller pinhole perforations.
3. 14 to 50 inches, a very light yellowish-gray or yellowish-white compact lime horizon of heavy silt loam that is hard and brittle when dry. The topmost 3 or 4 inches of this material is platy, and the plates have interlocking angular edges resembling mortise or masonry. Rootlets are matted in the cracks. Below this are tightly packed spherical aggregates, from ½ to ¾ inch in diameter. Breakage occurs along semiflattened contact faces, and the pieces are not distinct nodules. The lower part of this layer contains fewer of the round hard aggregates; they do not consist so completely of lime, and the parent material may be identified. Lime veining is prominent in the transition to the horizon below.
4. 50 to 90 inches, very light yellowish-brown or cream-colored uniform loess of silty texture, containing some very fine sand. This material is soft and crumbles easily to a loose floury mass resembling rock flour.

The Sagemoor, Bannock, and Paul soils have similar regional morphological characteristics typical of the Sierozem of the region. The Sagemoor soils underlain by old lake clays apparently have been influenced by retarded subdrainage. This has caused a somewhat thinner and denser lime layer, the greater density appearing at the top of the horizon. The horizon above the lime layer in many places has a richer brown color, possibly due to oxidation, and is slightly more compact than in the Portneuf soils. This condition may be due to more active hydrolysis, but there is also the suggestion of slight solonetzlike development.

The Bannock soils, which are developed from gravelly alluvium modified by wind-laid materials, are very similar to the Portneuf soils in profile, but they are underlain abruptly by a porous gravel substratum. Infiltrated lime is discernible in places in these strata, and the greatest concentration of lime generally occurs directly above the gravel.

The Paul soils are similar to the Bannock in morphology but are more compact and somewhat browner above the lime concentration. The difference in color appears to be, at least in part, inherited from the parent materials, which are sediments accumulated in depressions and are largely erosion products from more highly organic soils occurring at higher elevations.

The Declo soils are younger than the Sagemoor. They are developed from old stratified lake-laid materials and modified by both stream and aeolian surface deposits. The stage of development, as indicated by the thinner lime layer and less compaction, is not so far advanced as in the Portneuf soil. The regional profile characteristics, however, are discernible. The Fingal soils are on a more recent terrace than the Declo soils but are of similar origin. Heavy clay strata near the surface have probably interfered with the normal soil-development processes. Though a thin lime horizon accumulates immediately above these clay strata, the youthful stage of development is shown by the lack of distinct regional profile characteristics. Salinization has resulted from waterlogging, largely since irrigation, and most of these soils are now Solonchaks. The Fingal soils in many places give reactions with phenolphthalein, indicating the presence of sodium carbonate.

The Wheeler soils developed from loess similar to that of the Portneuf soils do not have the well-developed definite characteristics of the regional profile found in the Portneuf, although, especially in some of the flatter areas, there is a youthful suggestion of that profile. The Wheeler soils occupy high bench positions where geologic erosion is active. The rate of erosion is such that the soil-development processes do not act for sufficient time to make much impression on the rapidly rejuvenated parent materials. In the flatter areas the soil is free from carbonates to a depth of several inches, but on the average rolling to steep relief the soils are calcareous at the surface. The geometric surface blocks or slabs of the regional profile are present, but no appreciable oxidation or compaction is evident in the horizon below. Calcium carbonate accumulates in a horizon several feet thick, but the regional pattern is only suggested.

Following is a description of a selected profile of Wheeler silt loam:

1. 0 to 3 inches, light brownish-gray noncalcareous silt loam, which forms prisms, blocks, or slabs, 3 to 5 inches in diameter and roughly pentagonal. These blocks are soft and porous or vesicular and are capped by a palty fragile surface crust.
2. 3 to 12 inches, mildly calcareous silt loam that is yellower than the layer above, firm or slightly compact, and has an indistinct coarse prismatic structure. This material breaks down rapidly to a loose floury mass.
3. 12 to 40 inches, very light brownish-gray loam that is slightly to moderately compact and contains lime veining and some softly cemented spherical nodules.
4. 40 to 80 inches, very light yellowish-brown, uniformly colored, loose floury loess.

Joffe's (*5*) suggestion that the Portneuf soil is solonetzlike is hardly supported by investigation in this survey. As compared with the Wheeler soil, determinations of total salts with the electrolytic bridge show the Portneuf soil to be the most highly leached soil in the area. Soluble salt is almost absent throughout the profile, whereas in the Wheeler 0.23 percent of soluble salts was found in the parent materials. Below the lime layer this condition exists, regardless of the fact that the parent loess of the Wheeler soil is many times as thick as that of the Portneuf. The thinner loess of the latter would suggest that the underlying basalt might restrict free percolation of water and this, in turn, inhibit leaching; but apparently movement is not impeded. On the other hand, the rapid run-off and accelerated erosion on the Wheeler soil cause ineffective leaching and the concentration of salt

at a slight depth, so that characteristics of a Desert soil seem to be predominant. More effective moisture saturation, leaching, and hydrolytic action apparently create the Portneuf profile characteristics. The brown color of the horizon above the lime layer possibly has been intensified slightly by oxidation.

The Ammon soils, whose parent materials are largely erosion products from the Wheeler soils, are obviously younger. They have been developed on progressively aggrading materials during the period in which the Wheeler soils were developing while subject to erosion. The Ammon soils are calcareous throughout, but no appreciable compaction or layer of accumulated lime has developed. In favorable smooth undisturbed positions a profile similar to that of the Wheeler appears to be developing.

The Rupert soils are developed on stratified wind-modified porous sandy materials that allow free and deep moisture percolation. The absence of an appreciable accumulation of lime indicates that the parent materials were free of lime or very slightly calcareous. The lime that occurs below a depth of about 30 inches appears to have accumulated largely from underground water sources that now are absent. The effective leaching has removed free carbonates to a depth of about 30 inches—almost double the depth of the normal regional profile.

Following is a description of the profile of Rupert fine sand, rolling phase:

1. 0 to 8 inches, dull grayish-brown loose fine sand to medium sand, with a pepper-and-salt appearance due to light-colored quartz and dark-colored basalt sand.
2. 8 to 20 inches, medium-brown or grayish-brown loamy fine sand with slight compaction. There is a sprinkling of gravel and a pepper-and-salt appearance, as in the surface horizon.
3. 20 to 32 inches, grayish-brown fine sand or loamy sand with less compaction than the horizon above. Quartzite gravel is scattered throughout, and black basalt sand is prominent.
4. 32 to 80 inches, washed stratified gray sand of higher gravel content than that in the horizon above. A light-gray cast results from lime accumulation, and the pepper-and-salt appearance from a high content of quartz and basaltic sand is very pronounced.

The relief is undulating, and the vegetation includes scattered sagebrush and coarse bunchgrasses.

The Winchester soils, which are closely associated with the Rupert soils, are developed on wind-laid sand overlying a basalt substratum. The shifting surface sands have prevented the development of any distinct profile characteristics. Slight development of horizons appears, probably because of leaching and oxidation.

The Beverly soils are very youthful and are dominated in profile characteristics by the original stratification. Their stage of development is immature because of the short time the soil-development agencies have acted on the parent materials. Their trend of development is in the direction of the Bannock soils. Unlike the other soils of the bottom lands, they are not sensibly modified by poor drainage and have little accumulation of organic matter.

The other soils of the bottom lands, consisting of members of the Onyx, Logan, Snake, and Gooch series, are limited in their profile development by imperfect drainage and moisture, which has pro-

moted accumulation of organic matter from the vegetation of grasses and water-loving plants. Mineral and organic residues also are included in the material eroded from higher lying soils. In the subsoils a fluctuating water table has caused alternating conditions of oxidation and reduction, giving rise to staining and mottling. Precipitation of minerals from solution occurs in most of these soils. This is most noticeable as calcium carbonate concretions in the Gooch series.

SUMMARY

The Blackfoot-Aberdeen area lies in the Snake River Plain of southeastern Idaho. It has an arid continental climate. A large part of the mean annual precipitation of 10.54 inches occurs as snow. As this precipitation is insufficient for farm crops, irrigation has to be resorted to for the satisfactory production of crops. Most of the area surveyed consists of valley floor, which has a smooth surface favorable for irrigation.

The agriculture is diversified. The larger part of the farm income is from cash crops, such as potatoes, sugar beets, and to a less extent small grains, peas, and beans. In certain parts of the area the production of alfalfa seed and clover seed is important. Alfalfa occupies a much larger acreage than any other crop and is useful not only for hay and seed but also as an essential part of the crop rotation to increase and maintain the fertility of the soil. A smaller yet substantial part of the farm income is derived from the sale of animal products. Livestock are fed most of the hay and small grains produced on the farms. Small grains are grown as nurse crops for alfalfa. Potatoes are commonly considered the most important crop, and other crops are grown in the rotation to maintain fertility or to stabilize the farm income when prices for potatoes are low. Certain localities are engaged almost exclusively in the production of alfalfa seed, for which the climate and the soils are favorable.

Deficiencies in organic matter and nitrogen are common in all the cultivated soils, and the availability of phosphate is limited, owing to the high content of lime, caused in part by irrigation water. Dominant differences in the productivity of the soils and in their suitability for use result from differences in their physical characteristics, which control moisture-holding capacity and drainage, and from differences in lay of the land, which determines irrigability.

The soils and land types are grouped, largely on the basis of physiographic position and relief, as follows: (1) Soils of the uplands, (2) soils of the terraces or valley floor, (3) soils of the bottom lands and depressions, and (4) miscellaneous land types.

In the soils of the uplands are included the Portneuf, Ammon, and Wheeler series. These soils are developed from deposits of fine windborne materials. They are comparatively uniform and have excellent moisture-holding properties. All the common crops of the area are grown on these soils where irrigated. The Wheeler soils are not farmed, as they lie too high to be irrigated by gravity flow.

The soils of the terraces or valley floor include soils developed over gravelly alluvium, old lake-laid silts and clays, and other sedimentary materials. Those underlain by the heavier sedimentary strata include members of the Sagemoor, Declo, and Fingal series.

Those underlain by gravel include members of the Bannock, Paul, Rupert, and Winchester series. The Sagemoor and Declo soils and the finer textured Paul and Bannock soils have very similar or slightly less productive capacity than the soils of the uplands, and the same crops are grown on them. The compact partly cemented lime layer in the Sagemoor soils somewhat resists the penetration of roots. Some areas of the Sagemoor and Declo soils are poorly drained and salt-affected. Most of the Fingal soils are poorly drained and are high in soluble salts, so that agricultural development is limited.

The soils underlain by gravel and sand have a wide range in thickness and texture of soil materials overlying the coarse porous substratum, with a correspondingly wide range in moisture-holding capacity, productivity, and suitability for cultivation. These soils are well to excessively drained and are free from soluble salts. The finer textured Paul and Bannock soils are excellent soils for farming and are productive of a large variety of crops. The more sandy and gravelly soils of these series are more droughty and less desirable. The soils of the Rupert and Winchester series are largely almost nonarable, although some alfalfa seed is grown on better areas of Rupert soils.

Soils of the bottom lands and depressions are included in the Beverly, Blackfoot, Onyx, Gooch, Snake, and Logan series. The Beverly soils are well or excessively drained, light-colored, and low in organic matter. They are used for about the same crops as are the soils of the uplands and valley floor, but they have a high water requirement and are not so productive as the better of those soils. The Snake soils are poorly drained and are intermediate in color and organic-matter content. They are used for pasture. The Blackfoot, Onyx, Gooch, and Logan soils are comparatively high in organic matter and are rather dark-colored. The Beverly, Blackfoot, and Onyx soils are well drained and highly productive, although crop adaptations are somewhat limited. The Gooch and Logan soils are poorly drained and are used only for the production of native hay and pasture.

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U. S. GOVERNMENT PRINTING OFFICE: 1943

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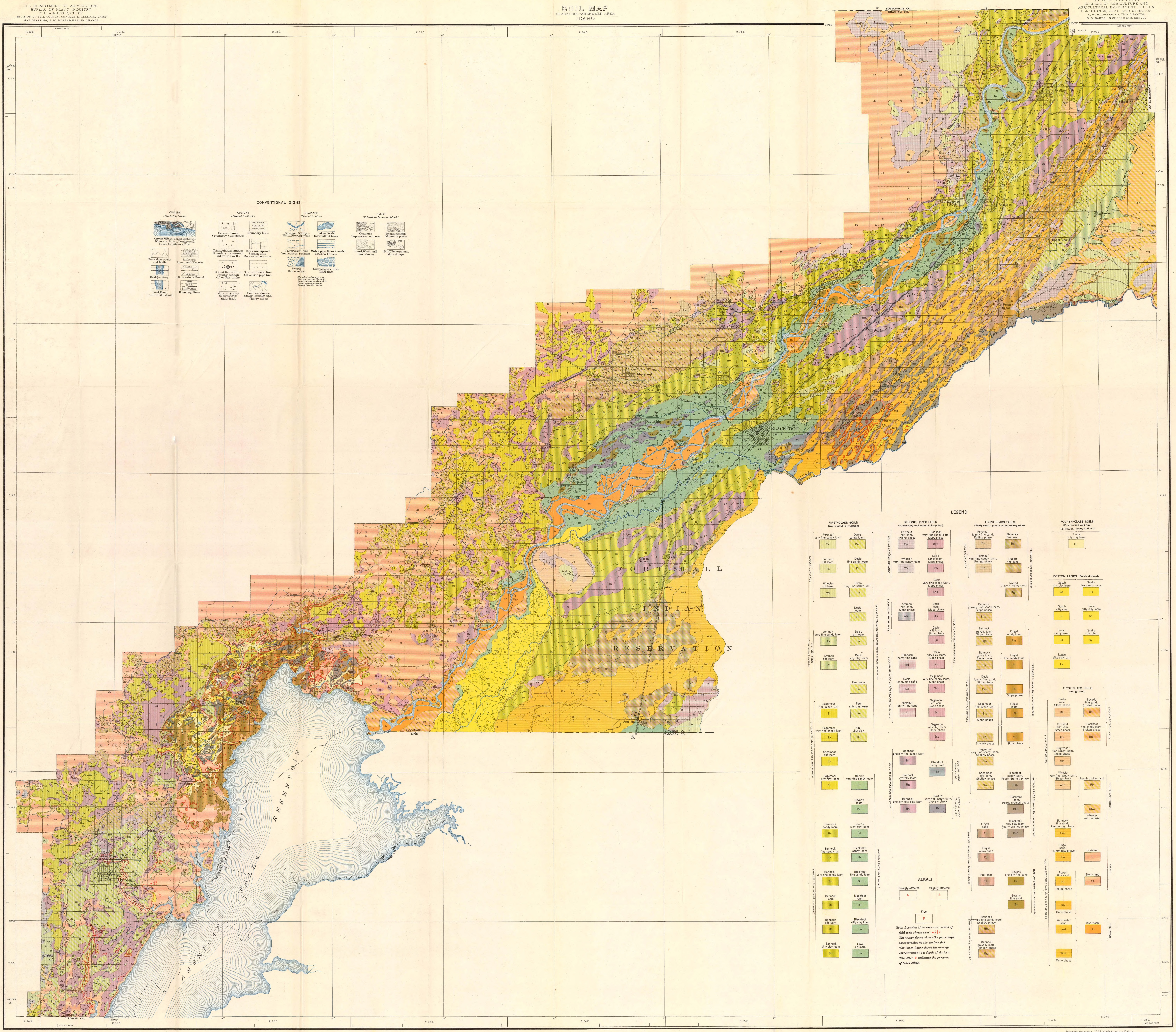
U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
E. C. AUCHTER, CHIEF
DIVISION OF SOIL SURVEY, CHARLES E. KELLOGG, CHIEF
MAP DRAFTING, J. W. MCKERICHER, IN CHARGE

SOIL MAP
BLACKFOOT-ABERDEEN AREA
IDAHO

UNIVERSITY OF IDAHO
COLLEGE OF AGRICULTURE AND
AGRICULTURAL EXPERIMENT STATION
E. J. IDDINGS, DEAN AND DIRECTOR
C. W. HUNGERFORD, VICE DIRECTOR
G. O. BAKER, IN CHARGE SOIL SURVEY



Macy H. Lapham, Inspector, District 5.
Soils surveyed by E. N. Poulson, U. S. Department of Agriculture, in charge,
and L. B. Nelson and A. E. Poulson, University of Idaho.

Polyconic projection, 1927 North American Datum.
Horizontal control by U. S. C. and G. S., and U. S. G. S.
Base map in part from U. S. Geological Survey Sheets.
10000 foot grid based upon Idaho (East) system of plane coordinates.
Surveyed in 1935-37. Series 1937.